October 1995

Vol. 19 No. 10

NASA Tech Briefs

The Design/Engineering Technology Digest

Data Acquisition & Analysis

Engine R&D Heats Up At NASA Lewis

The Net-Designed Composite XCAR

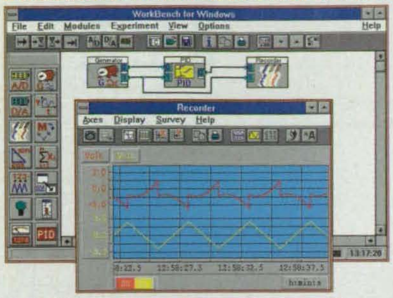
Where Do I Find Everything for Data Acquisition and Analysis?

ISO 9001 CERTIFIED CORPORATE QUALITY

OMEGA...Of Course!

OMEGA Advantage- Technical Support FREE

Workbench for Windows Icon-Driven Software



NEW™

Model SWD-WBWIN
$995
Basic Unit

Circle No. 616 or Request Document #6316, OMEGAfax Service

Portable Data Acquisition Systems For Notebook and Desktop PC's

NEW™

DAQBOOK Series
$1195
Basic Unit

Circle No. 616 or Request Document #6256, OMEGAfax Service

Advanced High Performance Fixed I/O PLC System

110CPU Series
$380
Basic Unit

NEW™

Circle No. 616 or Request Document #6315, OMEGAfax Service

To Request Your FREE OMEGA Universal Guide to Data Acquisition and Computer Interfaces™ Request Document #9988, OMEGAfax Service, or Circle No. 615

Plug-in Boards for IBM PC/XT/AT

Portable, Low Cost NOMAD™ Temperature and Temperature/Humidity Dataloggers

NOMAD
$135
Basic Unit

NEW™

Circle No. 616 or Request Document #6358, OMEGAfax Service

NEW™

WB-AAI/ASC/FAI Series
$784
Basic Unit

Circle No. 616 or Request Document #6137, OMEGAfax Service

DIN Rail Mount Signal Conditioners

NEW™

DRN Series
$295
Basic Unit

Circle No. 616 or Request Document #1581, OMEGAfax Service

OMEGAfax℠ FREE!

OMEGA's 24-Hour-a-Day, On-Demand Publishing Service

Call 1-800-848-4271

from any Touch-Tone phone, and just enter the OMEGAfax numbers for the products you're interested in. A product specification sheet will be faxed to you automatically. Don't forget to have your fax number handy!

OMEGA®

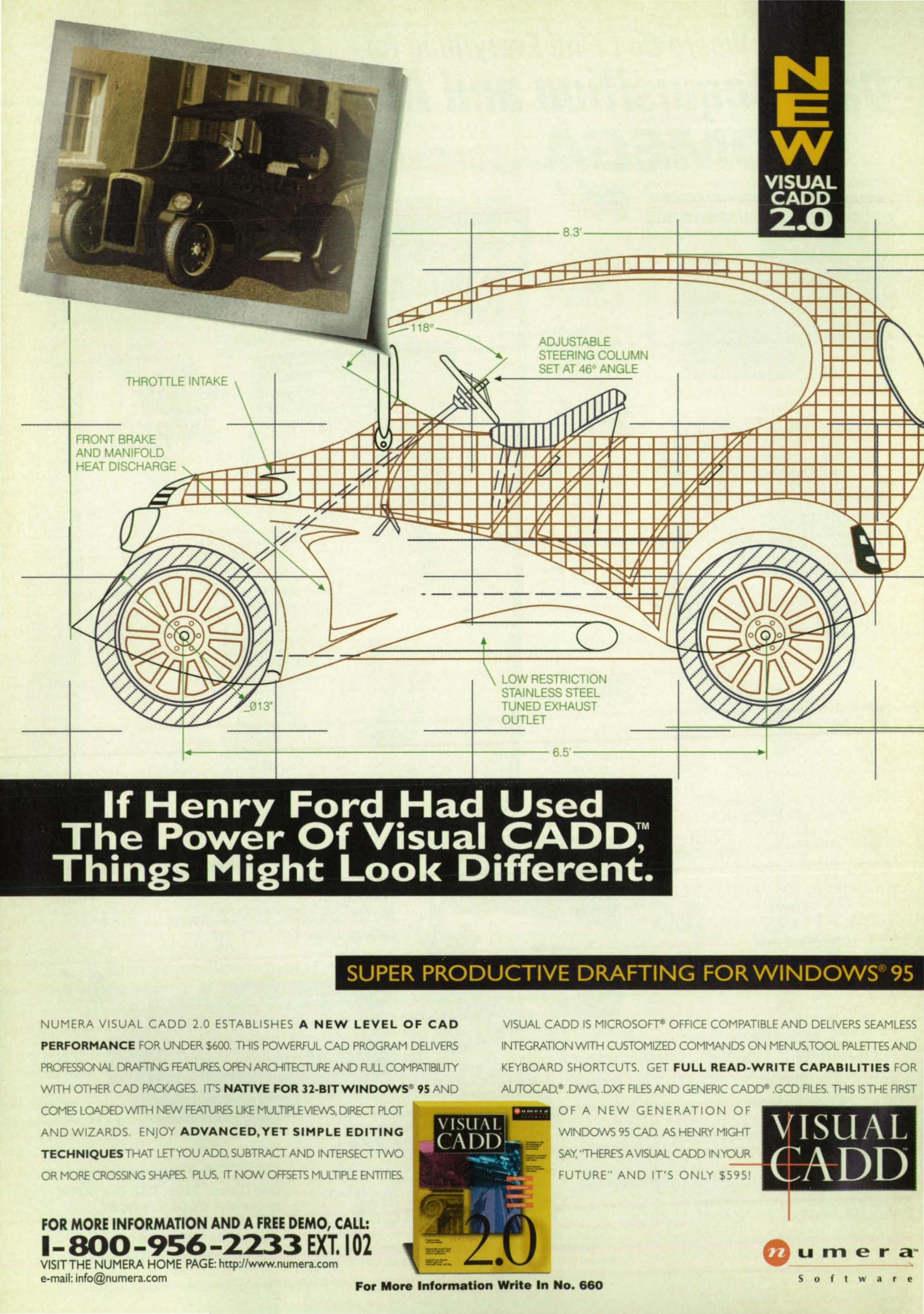
An OMEGA Technologies Company

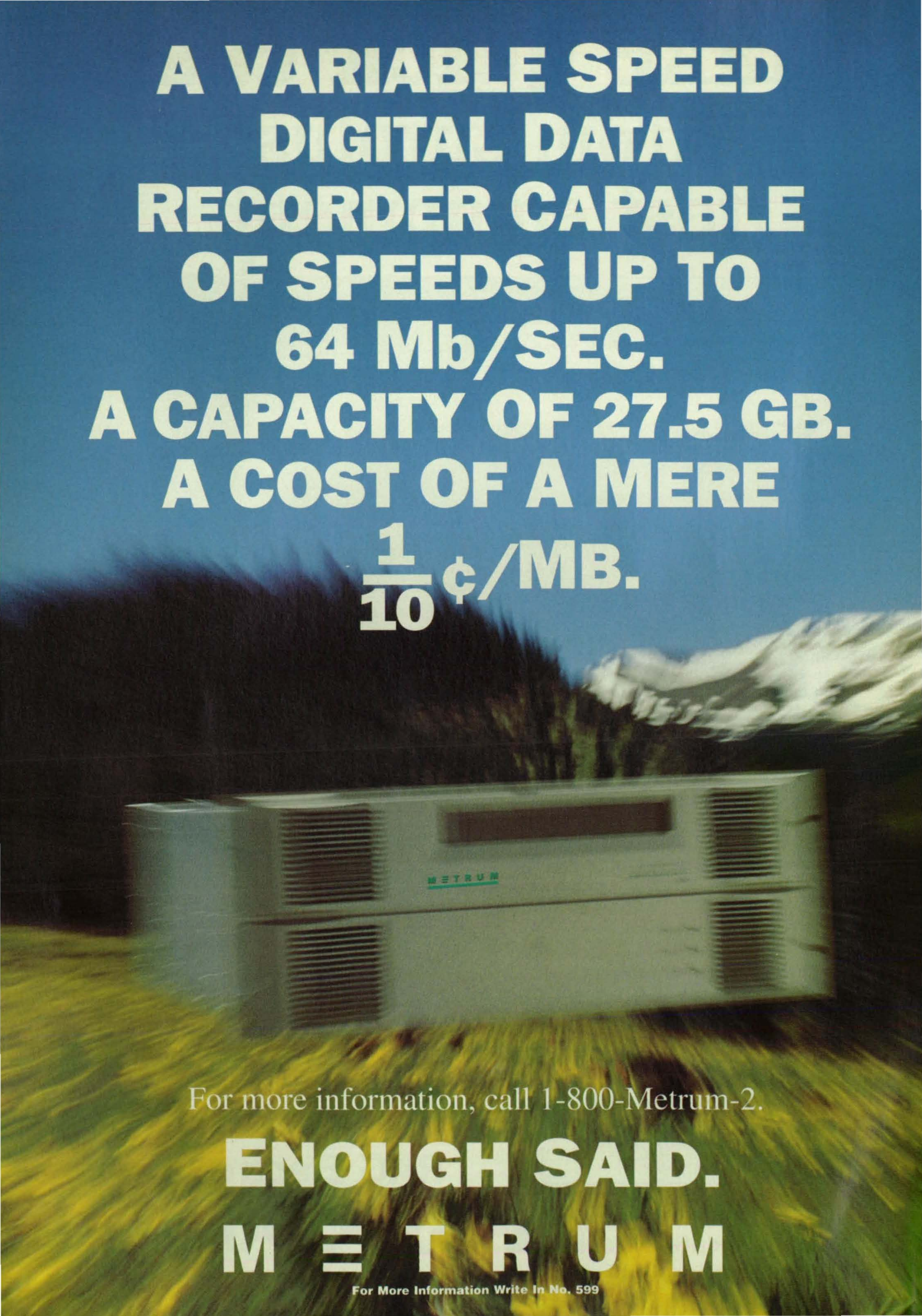
For Sales and Service Call:

1-800-82-66342℠
1-800-TC-OMEGA

OMEGA is pleased to announce OMEGAnet℠ On-Line Services! See OMEGA on-line on IndustryNet Information Service. –*Via Modem:* (412) 967-5363 –*Via Internet:* http://www.industry.net/omega

OMEGA Engineering, Inc.
One Omega Drive, P.O. Box 4047
Stamford, CT 06907-0047
Tel: (203) 359-1660
Fax: (203) 359-7700


NEW
VISUAL CADD 2.0
8.3'
118°
ADJUSTABLE STEERING COLUMN SET AT 46° ANGLE
THROTTLE INTAKE
FRONT BRAKE AND MANIFOLD HEAT DISCHARGE
LOW RESTRICTION STAINLESS STEEL TUNED EXHAUST OUTLET
_Ø13"
6.5'
If Henry Ford Had Used The Power Of Visual CADD™, Things Might Look Different.
SUPER PRODUCTIVE DRAFTING FOR WINDOWS® 95
NUMERA VISUAL CADD 2.0 ESTABLISHES A NEW LEVEL OF CAD PERFORMANCE FOR UNDER $600. THIS POWERFUL CAD PROGRAM DELIVERS PROFESSIONAL DRAFTING FEATURES, OPEN ARCHITECTURE AND FULL COMPATIBILITY WITH OTHER CAD PACKAGES. IT'S NATIVE FOR 32-BIT WINDOWS® 95 AND COMES LOADED WITH NEW FEATURES LIKE MULTIPLE VIEWS, DIRECT PLOT AND WIZARDS. ENJOY ADVANCED, YET SIMPLE EDITING TECHNIQUES THAT LET YOU ADD, SUBTRACT AND INTERSECT TWO OR MORE CROSSING SHAPES. PLUS, IT NOW OFFSETS MULTIPLE ENTITIES.
VISUAL CADD IS MICROSOFT® OFFICE COMPATIBLE AND DELIVERS SEAMLESS INTEGRATION WITH CUSTOMIZED COMMANDS ON MENUS, TOOL PALETTES AND KEYBOARD SHORTCUTS. GET FULL READ-WRITE CAPABILITIES FOR AUTOCAD,® .DWG, .DXF FILES AND GENERIC CADD® .GCD FILES. THIS IS THE FIRST OF A NEW GENERATION OF WINDOWS 95 CAD. AS HENRY MIGHT SAY, "THERE'S A VISUAL CADD IN YOUR FUTURE" AND IT'S ONLY $595!
VISUAL CADD 2.0
VISUAL CADD™
numera™ Software
FOR MORE INFORMATION AND A FREE DEMO, CALL:
1-800-956-2233 EXT. 102
VISIT THE NUMERA HOME PAGE: http://www.numera.com
e-mail: info@numera.com
For More Information Write In No. 660


A VARIABLE SPEED DIGITAL DATA RECORDER CAPABLE OF SPEEDS UP TO 64 Mb/SEC.
A CAPACITY OF 27.5 GB.
A COST OF A MERE $\frac{1}{10}$¢/MB.
METRUM
For more information, call 1-800-Metrum-2.
ENOUGH SAID.
METRUM
For More Information Write In No. 599

October 1995
Volume 19 Number 10

Contents

NASA Tech Briefs

Transferring Engineering Technology
to Over 200,000 Qualified Readers
Throughout Industry and Government

(continued on page 8)

Pratt & Whitney's 22" Advanced Ducted Propeller low-noise fan model is tested in the 9' x 15' wind tunnel at Lewis Research Center. Lewis' focus on aeropropulsion research includes efforts in advanced subsonic transport. For more information on facilities and opportunities at Lewis, see the Resource Report on page 24.

Photo courtesy of Lewis Research Center

At 200 MB Per Minute, We're Setting The Pace.

TRUE COMPATIBILITY WITH

Alliant	Macintosh
Alpha Micro	McDonnell Douglas
Altos	Motorola
Apollo	NCR
Arix	NeXT
AT&T	Novell
Basic-4	OS/2
Concurrent	PS/2
Convergent	Parallel Port
Data General	PC 386/ix
DEC SCSI	PC MS-DOS
DEC BI-Bus	PC Xenix/Unix
DEC DSSI	Pertec
DEC HSC	PICK
DEC Q-Bus	Plexus
DEC TU/TA81	Prime
DEC Unibus	Pyramid
Gould/Encore	Sequent
HP	Silicon Graphics
IBM AS/400	STC
IBM Mainframe	Stratus
IBM RISC/6000	Sun
IBM RT	Texas Instruments
IBM S/38	Unisys
ICL	Ultimate
Intergraph	Wang
	— and more

The CY-ASP is the fastest digital data storage solution on the market, able to store up to 70 GB at speeds of up to 200 MB per minute, unattended.

But there's more.

The fastest subsystem is also the most flexible, giving you a choice of four recording modes plus offline copy and verify functions.

In ***Single Mode*** the drives operate independently.

In ***Cascade Mode*** data automatically writes to the next tape once the previous tape is full.

In ***Mirroring Mode*** the same data writes to multiple tapes simultaneously.

In ***Striping Mode*** data writes to two or more tapes at once, maximizing throughput.

Consider it a data storage management tool, a solution that will help you solve the problems you encounter every day: the need for higher capacity and speed, the need to make duplicate tapes for off-site storage and data exchange, the need for real-time status information, and the need to save resources and boost productivity on every level.

Of course, we also know that a storage solution is only as good as the data you get back. With a bit error rate of less than 1 in 10^{17} bits read, the CY-ASP gives you the *highest* data integrity.

Based on proven 8mm helical scan technology, each drive supports our switch-selectable *data compression* option. And each drive features a 2-line, 40-column backlit display that gives complete status information.

Backed by a two year warranty that includes expert service and support from our in-house engineering group, the CY-ASP is setting the pace in performance, flexibility and value.

Other configurations are available, ranging from a 2.5 GB subsystem to an intelligent, automated 3 TB tape library. And they're all compatible with the widest range of computer systems and networks.

When you're ready for a data storage solution that means business, call for complete information.

(804) 833-9000

CYBERNETICS

Tera One • Yorktown, Virginia 23693 • Fax (804) 833-9300

For More Information Write In No. 504

Contents *(continued)*

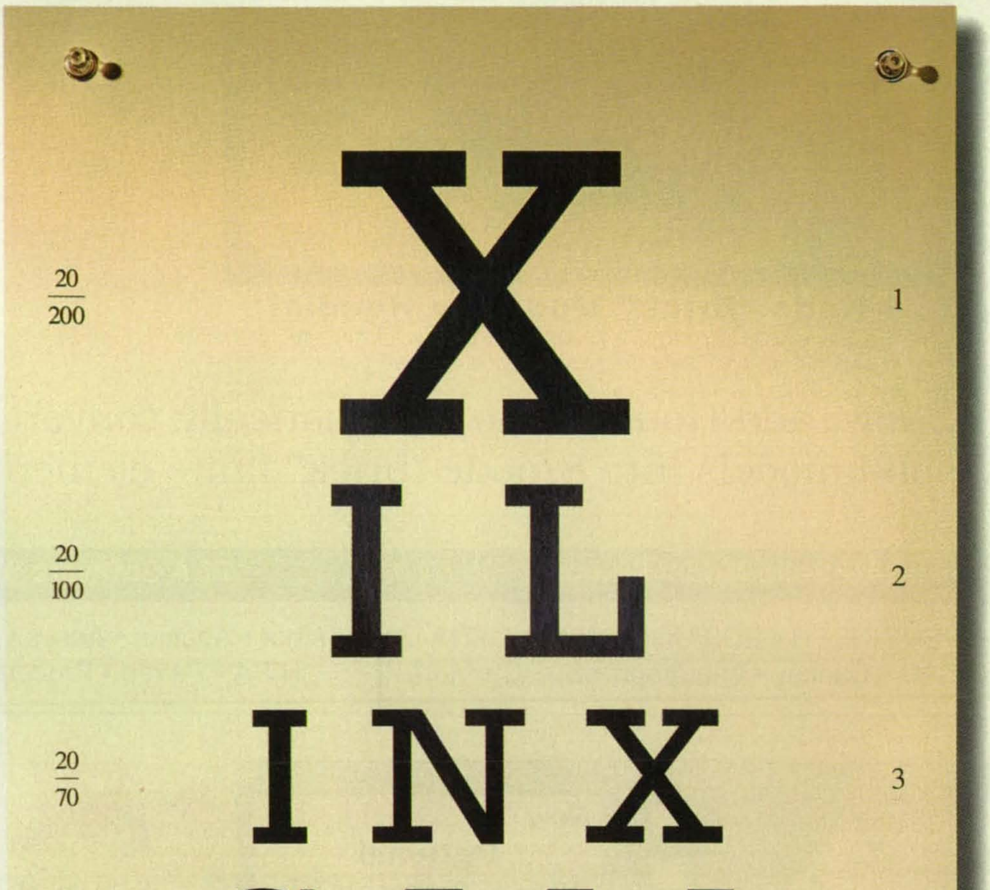
On the cover:
Using a computer network that reached across California, XCORP of Beverly Hills designed the XCAR, a fuel-efficient, low-emission, composite, recyclable car. A consortium of suppliers, defense labs, and NASA developed the prototype. An XCAR model will be one of the cutting-edge transportation innovations on display in the Transportation Tomorrow pavilion at Technology 2005 (October 24-26). For more information on the XCAR, see NASA Innovations on page 20.

Photo manipulation and digital collage by Douglas Mcdonald
Photo courtesy of XCORP

NASA Tech Briefs, ISSN 0145-319X, USPS 750-070, copyright © 1995 in U.S. is published monthly by Associated Business Publications Co., Ltd., 317 Madison Ave., New York, NY 10017-5391. The copyright information does not include the (U.S. rights to) individual tech briefs that are supplied by NASA. Editorial, sales, production, and circulation offices at 317 Madison Ave., New York, NY 10017-5391. Subscription for non-qualified subscribers in the U.S., Panama Canal Zone, and Puerto Rico, $75.00 for 1 year; $125 for 2 years; $200.00 for 3 years. Single copies $10.00. Foreign subscriptions one-year U.S. Funds $195.00. Remit by check, draft, postal, express orders or VISA, MasterCard, and American Express. Other remittances at sender's risk. Address all communications for subscriptions or circulation to NASA Tech Briefs, 317 Madison Ave., New York, NY 10017-5391. Second-class postage paid at New York, NY and additional mailing offices.

POSTMASTER: Please send address changes to NASA Tech Briefs, P.O. Box 10523, Riverton, NJ 08076-0523

HOW TO
YOU'RE REALL



TELL IF
Y FARSIGHTED.

You can't exactly make visionary products, unless, of course, you have the parts to go with them.

And there's no better place to go for visionary parts than right here.

At Xilinx, we have a track record for helping forward-looking companies meet their production deadlines.

Figure A.

Want specifics?

Here are a few of the far-sighted companies that have come to rely on Xilinx.

A. *Key Technology uses Xilinx FPGAs to give vision to their machines. In this case, camera-controlled scanners that can spot a bad strawberry and eject it while moving 272 cm per second.*

Figure B.

B. *Want to make an ordinary PC perform like a super-computer? Giga Operations Corp uses Xilinx FPGAs as Reconfigurable Computers to supercharge all sorts of applications, including real time video editing, telecommunications, and database processing.*

Figure C.

C. *Thanks to Xilinx FPGAs, the doctor really can see you now. MuTech developed a PCI board that works with today's Pentium and Power PC computers to deliver an affordable method of diagnosing problems in real time.*

D. *StrataCom uses Xilinx FPGAs to deliver the WAN systems their customers need today, while developing the broadband ATM solutions they'll definitely need tomorrow.*

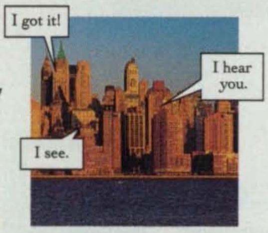


Figure D.

So if your company has any big projects on the horizon, you owe it to yourself to keep Xilinx in mind.

After all, if we can't help you with your vision, who can?

To find out more about our visionary parts, call us at 1-800-231-3386 or contact us at http://www.xilinx.com

XILINX®

The Programmable Logic Company.℠

For More Information Write In No. 683

NASA Tech Briefs

Published by .... Associated Business Publications
President/Chief Executive Officer .... Bill Schnirring
Publisher .... Joseph T. Pramberger
Senior Editor .... Linda L. Bell
Editor, Federal Lab Tech Briefs .... Robert Clark
Production Manager .... Donna Pituras
Advertising Coordinator .... Margery Koen
Art Director .... Lois Erlacher
Production Artist .... Brian Edgar
Circulation Director .... Martin J. Horan
Assistant Circulation Director .... Lori Coppin
Telemarketing Specialist .... Evelyn Mars
Assistant to Reader Service Manager .... Damiana Garcia

BRIEFS & SUPPORTING LITERATURE: Written and produced for NASA by **Advanced Testing Technologies, Inc.**, Commack, NY 11725
Technical/Managing Editor .... Ted Selinsky
Sr. Technical Analyst .... Dr. Larry Grunberger
Art Manager .... Eric Starstrom
Administrator/Chief Copy Editor .... Greg Galitzine
Staff Writers/Editors .... Dr. Theron Cole, George Watson, Howard Falk, Gail Pyke
Graphics .... Robert Simons
Editorial & Production .... Joan Schmiemann, Caroline Weaver, Becky D. Bentley

NASA:
NASA Tech Briefs are provided by the National Aeronautics and Space Administration, Technology Transfer Division, Washington, DC:
Administrator .... Daniel S. Goldin
Director, Commercial Technology .... Robert Norwood
Manager, Technology Transfer Office, NASA Center For AeroSpace Information .... Walter M. Heiland

ASSOCIATED BUSINESS PUBLICATIONS
317 Madison Avenue, Suite 921, New York, NY 10017-5391
(212) 490-3999 FAX (212) 986-7864
President/Chief Executive Officer .... Bill Schnirring
Executive Vice President/Chief Operating Officer .... Domenic A. Mucchetti
Treasurer .... Joseph T. Pramberger
Credit/Collection .... Felecia Lahey
Staff Accountant .... Larry Duze
Trade Show Director .... Wendy S. Janiel
Trade Show Manager .... Tricia Palumbo
Exhibition Sales .... Wayne Pierce
Trade Show Coordinator .... Tracy A. Wenz
Human Resources Manager .... Lourdes Del Valle
MIS Manager .... Ted Morawski
Assistant MIS Manager .... Pak Tong
MIS Data Entry .... Roxanne Portella
Office Manager .... Sylvia Valentin
Mailroom Operations .... Thomas C. Snyder, Rose D'Addozio
Administrative Assistant .... Christine Saluzzi

***NASA TECH BRIEFS* ACCOUNT EXECUTIVES**
NY, NJ (Area Code 201) .... Doug Shaller at (212) 490-3999
PA, DE, NJ (Area Code 908, 609), VA, DC, MD, WV .... Tara Morie at (610) 640-3118
Eastern MA, NH, ME, RI .... Paul Gillespie at (508) 429-8907
Bill Doucette at (508) 429-9861
Western MA, CT, VT .... George Watts at (802) 875-3310
Southeast, South Central .... Robert Hubbard at (910) 299-7754
OH, MI, IN, KY .... Louise Clemens at (216) 479-6868
IL, WI, MO, IA, MN, ND, SD, NE, KS .... Melinda Mead at (312) 296-2040
N. Calif., CO .... Bill Hague at (415) 974-1211
WA, OR, ID, MT, WY .... Bill Madden; Bill Hague at (206) 858-7575
S. Calif., (Area Codes 909, 818, 805, 213, 310), NV, UT .... Tom Stillman at (310) 372-2744
S. Calif., (Area Codes 619, 714), AZ, NM .... Richard Ayer; Jane Hayward at (714) 366-9089
Japan .... Akio Saijo at 03 (5691) 3335

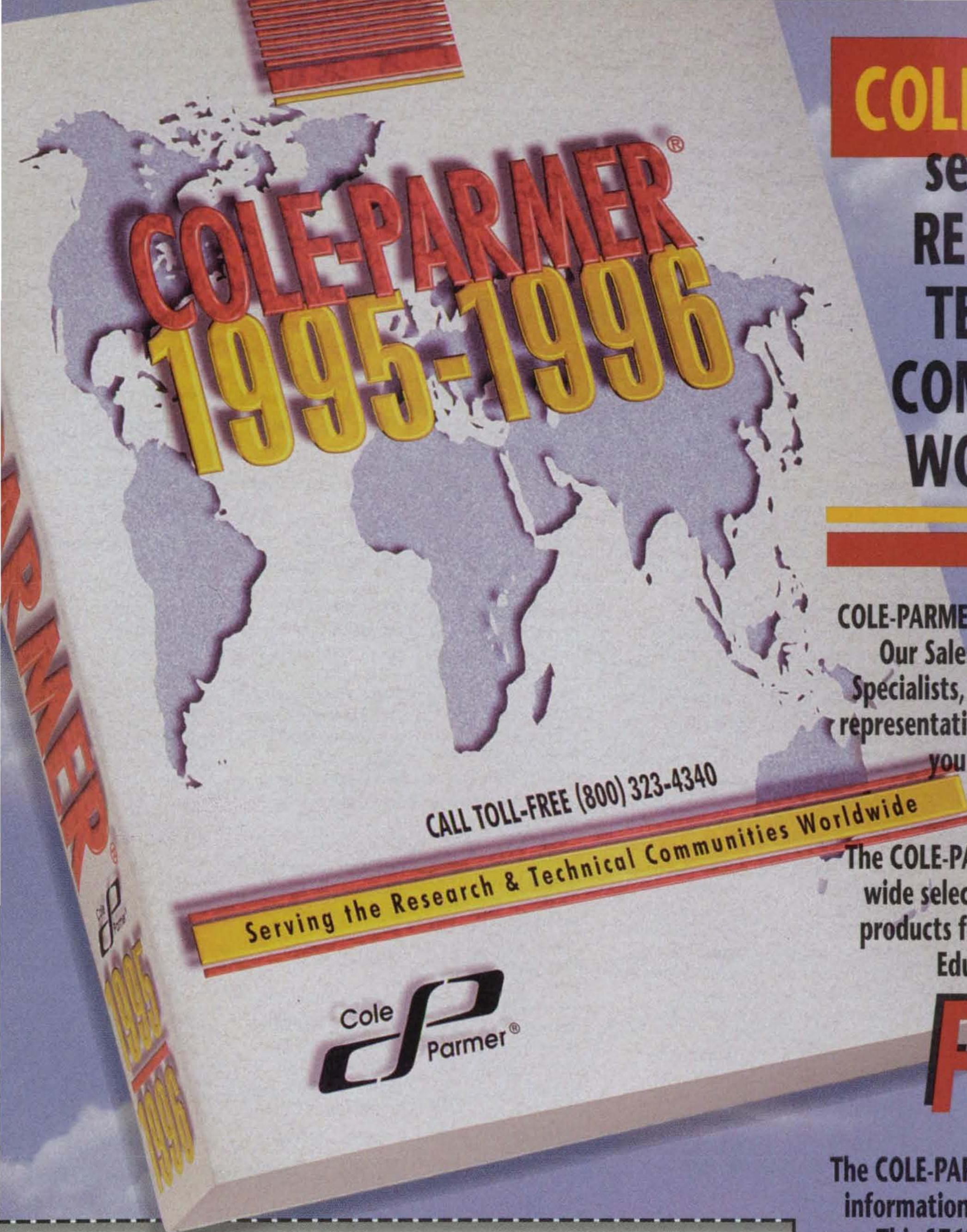
How To Reach Us On Line

Letters to the editor: ntb_edit@interramp.com

To find out about advertising opportunities: ntb_advertise@interramp.com

For information on the Technology 2005 conference (October 24-26, Chicago): http://www.keds.com/tech2005

NASA Tech Briefs home page: http://www.keds.com/ntb


COLE-PARMER®
1995-1996
CALL TOLL-FREE (800) 323-4340
Serving the Research & Technical Communities Worldwide
Cole Parmer®

NASA Commercial Technology Team

NASA's R&D efforts produce a robust supply of promising technologies with applications in many industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of commercial technology organizations. The network includes ten NASA field centers, six Regional Technology Transfer Centers (RTTCs), the National Technology Transfer Center (NTTC), business support organizations, and a full tie-in with the Federal Laboratory Consortium (FLC). We encourage all businesses with technical needs to contact the appropriate organizations for more information. For those who have access to the Internet, general information can be accessed with Mosaic software on the NASA Commercial Technology Home Page at URL: http://nctn.oact.hq.nasa.gov. Instructions regarding how to acquire the free Mosaic software can be obtained by sending an e-mail request to: innovation@oact.hq.nasa.gov.

NASA's Technology Sources

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP) indicated at the end of the brief. If a TSP is not available, the Commercial Technology Office at the NASA field center that sponsored the research can provide you with additional information and, if applicable, refer you to the innovator(s). These centers are the source of all NASA-developed technology.

Ames Research Center
Selected technological strengths: Fluid Dynamics; Life Sciences; Earth and Atmospheric Sciences; Information, Communications, and Intelligent Systems; Human Factors.
Syed Shariq
(415) 604-0753
syed_shariq@qm gate.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.
Lee Duke
(805) 258-3119
duke@louie.dfrf.nasa.gov

Goddard Space Flight Center
Selected technological strengths: Earth and Planetary Science Missions; LIDAR; Cryogenic Systems; Tracking; Telemetry; Command.
George Alcorn
(301) 286-5810
galcorn@gsfc-mail.nasa.gov

Jet Propulsion Laboratory
Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.
Wayne Schober
(818) 354-2240
wayne.r.schober @jpl.nasa.gov

Johnson Space Center
Selected technological strengths: Artificial Intelligence and Human Computer Interface; Life Sciences; Human Space Flight Operations; Avionics; Sensors; Communications.
Hank Davis
(713) 483-0474
hdavis@gp101.jsc.-nasa.gov

Kennedy Space Center
Selected technological strengths: Emissions and Contamination Monitoring; Sensors; Corrosion Protection; Bio-Sciences.
Bill Sheehan
(407) 867-2544
billsheehan@ ksc.nasa.gov

Langley Research Center
Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
Charlie Blankenship
(804) 864-6005
c.p.blankenship @larc.nasa.gov

Lewis Research Center
Selected technological strengths: Aeropropulsion; Communications; Energy Technology; High Temperature Materials Research.
Walter Kim
(216) 433-3742
wskim@lims01. lerc.nasa.gov

Marshall Space Flight Center
Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.
Harry Craft
(800) USA-NASA
susan.van.ark@ msfc.nasa.gov

Stennis Space Center
Selected technological strengths: Propulsion Systems; Test/Monitoring; Remote Sensing; Nonintrusive Instrumentation.
Anne Johnson
(601) 688-3757
ajohnson@ssc. nasa.gov

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium.

Lee Rivers
National Technology Transfer Center
(800) 678-6882

Robert Stark
Far-West Technology Transfer Center
University of Southern California
(800) 642-2872 or
(213) 743-2353

Dr. William Gasko
Center for Technology Commercialization
(800) 472-6785 or
(508) 870-0042

J. Ronald Thornton
Southern Technology Applications Center
University of Florida
(800) 472-6785 or
(904) 462-3913

Gary Sera
Mid-Continent Technology Transfer Center
Texas A&M University
(800) 472-6785 or
(409) 845-8762

Lani S. Hummel
Mid-Atlantic Technology Applications Center
University of Pittsburgh
(800) 472-6785 or
(412) 648-7000

Chris Coburn
Great Lakes Industrial Technology Center
Battelle Memorial Institute
(800) 472-6785 or
(216) 734-0094

Easy Access To The FLC: Call (206) 683-1005 for the name of the Federal Laboratory Consortium Regional Coordinator in your area. The Regional Coordinator, working with the FLC Locator, can help you locate a specific laboratory to respond to your needs.

NASA Program Offices

At NASA Headquarters there are seven major program offices that develop and oversee technology projects of potential interest to industry. The street address for these strategic business units is: NASA Headquarters, 300 E St. SW, Washington, DC 20546.

Gene Pawlik
Small Business Innovation Research Program (SBIR)
(202) 358-4661
gpawlik@oact.hq. nasa.gov

Robert Norwood
Office of Space Access and Technology (Code X)
(202) 358-2320
rnorwood@oact.hq. nasa.gov

Philip Hodge
Office of Space Flight (Code M)
(202) 358-1417
phodge@osfms1.hq. nasa.gov

Gerald Johnson
Office of Aeronautics (Code R)
(202) 358-4711
g_johnson@aeromail. hq.nasa.gov

Bill Smith
Office of Space Sciences (Code S)
(202) 358-2473
wsmith@sm.ms.ossa. hq.nasa.gov

Bert Hansen
Office of Microgravity Science Applications (Code U)
(202) 358-1958
bhansen@gm.olmsa. hq.nasa.gov

Granville Paules
Office of Mission to Planet Earth (Code Y)
(202) 358-0706
gpaules@mtpe.hq. nasa.gov

NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

Dr. Stephen Gomes
American Technology Initiative
Menlo Park, CA
(415) 325-5353

Jill Fabricant
Johnson Technology Commercialization Center
Houston, TX
(713) 335-1200

John Gee
Ames Technology Commercialization Center
Sunnyvale, CA
(408) 734-4700

Dan Morrison
Mississippi Enterprise for Technology
Stennis Space Center, MS
(800) 746-4699

If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center,** (505) 277-3622.
For software developed with NASA funding, contact **NASA's Computer Software Management and Information Center (COSMIC)** at (706) 542-3265, fax (706) 542-4807.
If you have a questions...**NASA's Center for AeroSpace Information** can answer questions about NASA's Commercial Technology Network and its services and documents. Use the Feedback Card in this issue or call (410) 859-5300, ext. 245.

NASA PATENTS

Over the past three decades, NASA has granted more than 1000 patent licenses in virtually every area of technology. The agency has a portfolio of 3000 patents and pending applications available now for license by businesses and individuals, including these recently patented inventions:

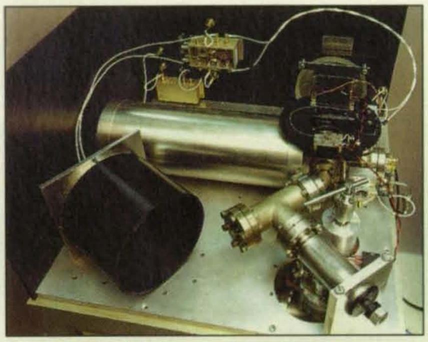
Image Data Compression Having Minimum Perceptual Error

(U.S. Patent No. 5,426,512)

Inventor: Andrew B. Watson, Ames Research Center

Image data compression helps reduce the load on communication network computer infrastructure by reducing redundancy, the number of bits, and invisible image-components–but perceptual error is often the cost. Mr. Watson's invention provides a method for compressing visual information, based on luminance masking, contrast masking, and error pooling, that provides a visually optimized image with high resolution and low perceptual error, minimizing such error for a given bit rate.

For More Information Write In No. 753



Extended Linear Ion Trap Frequency Standard Apparatus

(U.S. Patent No. 5,420,549)

Inventor: John D. Prestage, Jet Propulsion Laboratory

The low number of confined ions in a trapped ion-based frequency standard for atomic clocks leads to a low signal-to-noise ratio, limiting clock stability. The linear ion trap increases the number of trapped ions tenfold and gives a similar increase in clock stability. Dr. Prestage's new extended linear ion trap, with two ion-trap regions, requires magnetic shielding only in the second region and decreases by a hundredfold the volume of the region requiring shielding.

For More Information Write In No. 756

High-Energy-Density and High-Power-Density Ultracapacitors and Supercapacitors

(U.S. Patent No. 5,426,561)

Inventors: Shiao-Ping S. Yen and Carol R. Lewis, Jet Propulsion Laboratory

To increase efficiency sufficiently to make them practical, batteries for electric vehicle propulsion systems need low weight and volume, thus high energy and power densities in the capacitors. Ultracapacitors and supercapacitors have been devised to this end, but neither yet are sufficient for an electric vehicle propulsion system. Yen and Lewis' new ultracapacitor and supercapacitor designs replace the two discrete metal current collectors for anode and cathode with a single thin polymer film, reducing capacitor volume threefold and increasing energy density ninefold.

For More Information Write In No. 755

Mechanical Energy Absorber

(U.S. Patent No. 5,423,400)

Inventor: Clarence J. Wesselski, Johnson Space Center

Mechanical energy-absorbing systems often are sensitive to friction coefficient changes and extreme temperature changes, produce a sharp load spike at the beginning of a stroke, and require close manufacturing tolerances. The present invention employs diaphragm elements that frictionally engage the shaft and are opposed by a force-regulating set of disc springs that stabilize the load level even if the friction coefficient greatly increases. This force feedback counters the effects of manufacturing tolerances, sliding surface wear, temperature changes, dynamic effects, and lubricity.

For More Information Write In No. 751

Slow-Release Fertilizer

(U.S. Patent No. 5,433,766)

Inventors: Douglas W. Ming and Dadigamuwage C. Golden, Johnson Space Center

Mineral fertilizers such as apatite do not supply all nutrients, contain toxic elements, and often need micronutrient supplements. Also, multiple mineral phases diffuse in the soil at varying rates, offer little control over a plant's daily micronutrient needs, require large quantities because of soil impediments, and can be washed away. This slow-release fertilizer is a synthetic calcium phosphate apatite having agro-nutrients embedded in its crystalline structure, is free of toxins, and releases micronutrients as the apatite dissolves.

For More Information Write In No. 752

Extra-Corporeal Blood Access, Sensing, and Radiation Methods and Apparatuses

(U.S. Patent No. 5,429,594)

Inventor: Kent D. Castle, Johnson Space Center

The apparatuses have one or more access ports in tubing, through which blood flows, and with associated windows for either treating or analyzing the blood. Flow rate may be controlled for treatment radiation such as neutrons, ions, photons, or alpha particles; other possible treatments through the apparatus include heat, sound, electrical energy, or electrostatic force.

For More Information Write In No. 754

New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Commercial Technology Office of the sponsoring NASA center (see page 14).

Thin-Film Power Transformers

Microfabrication techniques would be used to produce these transformers. The proposed transformers could have geometric features finer than conventionally made models.
(See page 44.)

Process-Information Display Panel for Welder's Visor

A head-up display mounted on a welder's visor would supply key process information in real time. Such a display would help the welders to follow process parameters more uniformly and to guide new welders away from problems previously encountered by others.
(See page 48.)

Trioxane: a Fuel for Direct-Oxidation Fuel Cells

Trioxane can be used as a substitute for formaldehyde in these cells. The former has been identified as a high-energy, nontoxic, solid substitute for formaldehyde.
(See page 63.)

Closed-Loop System Removes Contaminants From Inert Gas

A limited quantity of inert gas is sufficient for processing semiconducting materials. The recycled gas is purified by cartridges that remove water vapor and oxygen. Porous metal filters remove particles.
(See page 64.)

Electrochemical Deposition of Thiolate Monolayers on Metals

One potential use of this method is fabrication of chemically selective thin-film resonators for microwave oscillators used to detect pollutants. Other uses are in selective chemical derivatization for improving adhesion, lubrication, protection against corrosion, electrocatalysis, and electroanalysis.
(See page 65.)

Predatory Microorganisms Would Help Reclaim Water

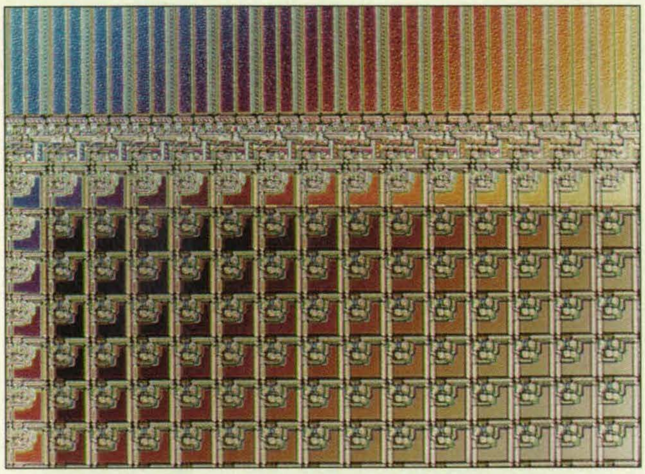
Harmless *Dictyostellium* amoebae can be used to advantage to consume pathogenic bacteria in wastewater, without toxic chemicals, intense heat, or ionizing radiation.
(See page 97.)

NASA INNOVATIONS

Technology 2005 (October 24-26 at Chicago's McCormick Place) will showcase an array of commercially promising inventions and processes developed by NASA's leading technologists. Here is a sampling.

Camera On A Chip

The Active Pixel Sensor (APS), developed at NASA's Jet Propulsion Laboratory, stores on a single computer chip all of the components necessary to produce an image. The camera-on-a-chip technology makes possible an imaging system that is smaller, less expensive, and more efficient than cur-



The Active Pixel Sensor stores on a single computer chip all components necessary to produce an image. Miniature, low-power, low-cost imaging systems are possible with the camera-on-a-chip technology.

rent charge-coupled device (CCD) imaging sensors, according to Dr. Eric Fossum, who led the development team at JPL. CCDs cost about $1000 per million pixels when made for low-volume applications. APS devices are made in a conventional integrated circuit facility for one-third what a similar wafer using the CCD process costs. The complementary metal-oxide semiconductor (CMOS) technology used to manufacture the APS is used for almost all microprocessors and memory chips.

Developed by JPL's Center for Space Microelectronic Technology for space applications, the sensor enables the manufacture of low-cost, low-power, miniature cameras with on-chip timing, control, and drive electronics. It can communicate directly with a microprocessor or computer.

Commercial uses include personal computer visual communications, advanced television, electronic still cameras, laboratory-based cameras, medical and nuclear instruments, toys, automobiles, and space-based surveillance systems. JPL has signed an agreement with AT&T for videoconferencing applications, and with Kodak for electronic photography.

A Powerful Alternative

NASA's Lewis Research Center has developed a thermophotovoltaic (TPV) power system that converts heat energy into electrical energy by coupling the heat energy to an emitter to produce infrared light. A low-bandgap photovoltaic device or solar cell, sensitive to IR light, is placed in front of the emitter to produce electricity. The thermal energy can come from any source, from fuel combustion to nuclear decay to concentrated solar energy.

Lewis researchers have developed two methods of converting thermal to radiant energy. One involves the use of a blackbody emitter, such as silicon carbide, to produce a broadband photon spectrum. A high-pass filter reflects the unusable photons back to the emitter, where they are adsorbed and aid in maintaining the emitter temperature.

The second method couples thermal energy to a selective emitter, which is composed of a rare earth oxide that has a characteristic emission band indicative of the rare earth element used in the emitter. Outside this band, the emitter produces little radiant energy. This method provides the highest system efficiency, but the blackbody/filter method supplies the highest power density. Both methods employ rare earth doped YAG crystals.

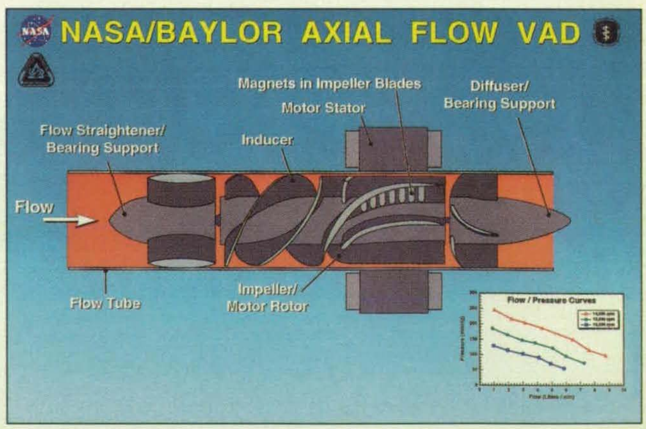
The small, lightweight, quiet TPV power systems have applications in remote/RV power, consumer and utility power generation, and in co-generation applications such as self-powered natural gas furnaces. The system also could provide electricity for an electric vehicle, resulting in reduced pollution since the fuel would burn more thoroughly at lower temperatures.

McDonnell-Douglas has teamed with Lewis to develop TPV power systems for utility scale power generation using concentrated sunlight.

Heart Helper

Developing a long-life implantable artificial heart is a goal of medical researchers worldwide. With no such product on the near horizon, NASA's Johnson Space Center has joined forces with Baylor College of Medicine to develop a Left Ventricle Assist Device (LVAD) that doesn't replace the heart, but supplements its pumping capacity in the left ventricle.

Tools and techniques used by NASA in spacecraft propulsion system component design were used in the design of the LVAD, which is a small, implantable, axial-flow pump that minimizes red blood cell trauma and thrombosis. The LVAD consists of three components: a flow straightener to direct the incoming flow axially and support the front bearing; an inducer/impeller (the only moving part)



A small, implantable pump supplements the heart's pumping capacity using only one moving part. The Left Ventricle Assist Device can assist a weak heart after surgery, maintain a heart until a transplant, or negate the need for a transplant.

that rotates between 10,000 to 12,000 revolutions per minute; and a diffuser that redirects the tangential flow and supports the rear bearing. There are no seals or diaphragms which can fatigue, fail, or

leak. Support equipment consists of a potentially implantable controller, and primary and secondary batteries.

The device provides temporary ventricular assistance to patients experiencing weak cardiac function after surgery. It will support the patient until the heart recovers, usually less than one month. The LVAD also can maintain the heart in a stable condition in patients requiring a total heart transplant until a donor is found, which can range from one month to one year. In some cases, the need for a transplant may be negated by permanent implantation of the LVAD, if the heart is stable but simply not able to produce sufficient blood flow.

The LVAD is 25% more efficient than other clinically available devices, which can restrict mobility and limit the size range of patients in which they can be implanted. An estimated 50,000 to 60,000 patients per year in the U.S. alone are in need of an implantable LVAD.

Generating Ozone by Electrolysis

Lynntech, Inc. of College Station, TX, teamed with NASA's Johnson Space Center to develop an electrochemical process of generating ozone for reclamation and repurification of wastewater in regenerative life support systems.

Ozone gas is a nonpolluting water treatment chemical with a growing number of commercial applications. When introduced into water, it breaks down into oxygen and water, leaving no harmful residual chemicals. It has become more widely used as a municipal drinking water disinfectant, replacing chlorine which produces more disinfection by-products.

Ozone cannot be stored as a compressed gas–it must be generated at the application site–and usually is made by the corona discharge process, which is expensive on a small scale due to high equipment costs. The new alternative process forms ozone electrochemically by the electrolysis of water, using ozone in combination with ultraviolet light.

Electrochemical ozonizers have a number of commercial applications, such as creating ozone for disinfecting ultra-high-purity water used in the manufacture of semiconductor devices. Hazardous wastewater containing organic pollutants can be treated using the new process, which eliminates the pollutants by oxidation, rather than transferring them from one place to another. The process creates a concentrated ozone source, generating a gas stream containing up to 20% ozone by weight. The higher concentrations generated by this process permit more effective transfer of ozone into a process stream.

Small-scale water recycling systems are becoming common, and alternative disinfectants to chlorine are being sought. Electrochemical ozonizers could serve this growing market in the U.S.

Green Machine

Renew, reuse, recycle. From paper bags to soup cans to soda bottles, virtually every type of packaging is recyclable. Now, NASA is helping to drive an innovation that could make your car totally recyclable.

The government's automobile standards for the future specify a low-emission, fuel-efficient, recyclable, affordable "Supercar." XCORP of Beverly Hills, CA–in cooperation with 36 aerospace and automotive engineers and NASA–has designed a concept car that could meet such requirements. The rear-wheel-drive, rear-engine XCAR features an all-composite monocoque chassis. It's expected to get up to 90 miles per gallon and reduce emissions by 80% compared to other vehicles. And if that's not enough, the car also would be wallet-friendly, sporting a sticker price between $10,000 and $13,000.

XCORP used a computer net across California to design the car, and a consortium of suppliers and defense labs has developed a prototype in conjunction with NASA's Far West Regional Technology Transfer Center at the University of Southern California. NASA Langley Research Center's fluid dynamics computer department will conduct crash simulations using the Internet, and a new rapid prototyping plant at the Department of Energy in Kansas City will produce the car's parts.

A class of materials called Environmental Composites (ECs) is mixed with aluminum to produce an inexpensive, recyclable, one-piece car body. The lightweight, strong, noncorrosive, nonconducting, vibration-dampening composites are made using a low-emission, low-energy manufacturing system. They even can be formulated from agricultural waste or recycled materials.

The XCAR can be manufactured using one-third as many parts as a conventional car, eliminating spot welding, drilling, bolting, and most finishing operations commonly used in the manufacture of steel cars. And when the XCAR has reached the end of its environmentally friendly road, it can be stripped easily and its main components, advanced polymers and aluminum, can be recycled.

An XCAR model will be featured in Technology 2005's "Transportation Tomorrow" exhibit pavilion of automotive, aviation, marine, and mass transport advances.

Seeing is Believing

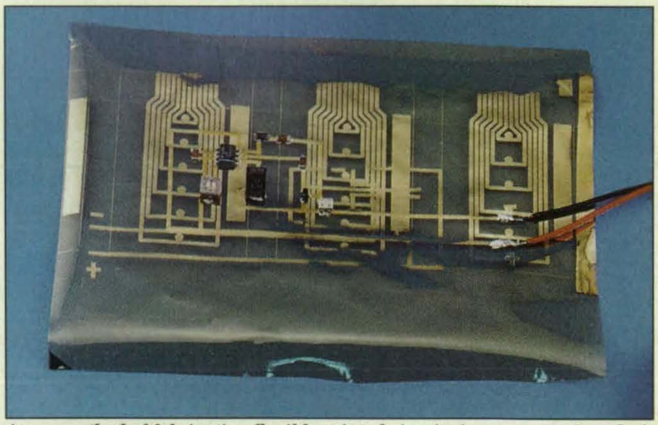
Affecting nearly 50 million people each year worldwide, cataracts remain the major cause of blindness. There is no medical treatment to prevent, halt, or reverse the progression of cataracts–surgery is the only recourse. A new method of detecting the onset of cataracts noninvasively eventually may be used to develop and test new drugs or diet therapies that could slow the formation of cataracts, or dissolve them, before surgery is required.

A compact fiber-optic probe developed for microgravity science experiments on the space shuttle has been applied to eye diagnostics through NASA's Lewis Research Center. The probe is based on dynamic light scattering principles and has no moving parts. It does not require optical alignment, and contains a miniature microscope for imaging the eye. The size of a pencil, the probe is positioned in front of the eye and delivers a low power cone of laser light into the eye. The light is back-scattered by the protein molecules of the lens through a receiving optical fiber to a photodetector. The system provides a means for studying physical properties of the anterior and posterior chambers of the eye.

The device detects not only cataracts but also diseases of the chambers and indicates patients affected by cholestrolosis. Complete eye diagnostic capabilities are provided to ophthalmologists in one small instrument package.

A Unique Plastic

A patented thermoplastic, developed by Robert Bryant at NASA's Langley Research Center, shows promise as a useful tool in almost all manufacturing processes. LaRC SI (soluble imide) is a moldable, soluble, strong, crack-resistant polymer that can survive at high temperatures and pressures. While originally designed for high-speed civilian aircraft, it promises to be useful in almost all manufacturing processes.



A new method of fabricating flexible printed circuits incorporates Langley's LaRC SI soluble polyimide. The method completely eliminates the use of adhesives and pressure bonding.

The polyimide is the highest-performing class of plastics. It is superior to epoxies, polyesters, and other materials since it can withstand hostile environments and be molded into any shape. It bonds to itself and is soluble only once, making it ideal for such applications as multilayer flexible circuits.

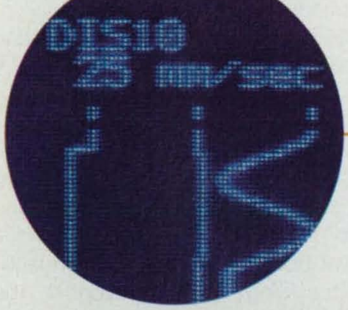
The thermoplastic is based on readily available compounds. When melted, it can be painted or sprayed onto a surface, where it hardens when dry. LaRC SI is unlikely to burn, and is resistant to hydrocarbons, lubricants, antifreeze, hydraulic fluid, and detergents found in manufacturing environments. It also can be used as a base film or adhesive for use by manufacturers of mechanical parts, abrasive coatings and thin films.

For more information on these technologies, contact the NASA field center that sponsored the research (see page 14). For information on Technology 2005, call 1-800-633-0062, ext. 117.

NEW FROM ASTRO-MED!

30 Channels! Brilliant Monitor! Huge Memory! Laser Resolution Chart!

TRUE FIELD RECORDER®



- Bright, High Response Monitor
- 10, 20 or 30 Waveform Channels
- Laser Quality (300 dpi) Chart Resolution
- Huge 512 KSample Memory per Channel for Data Capture and Analysis
- True Portability: Internal Battery and AC
- Record up to 500 V Peak (Isolated) at 25 kHz Response
- Analyze Data with FFT, etc.
- On-Board Floppy Drive for Setup and Memory Transfer
- Wide Format 11-Inch Chart

The all-new Dash 10 lets you receive up to 30 waveform channels (DC to 25 kHz), see the data in real time on the bright high-speed vacuum fluorescent monitor, record with laser quality fidelity, and *at the same time* capture the data for playback and analysis. Now you can do all this on a truly portable package powered by internal battery or AC. The Dash 10 comes with a powerful software package, has a floppy disk for updates and data archiving, plus RS-232 and GPIB.

Phone, fax or write for details!

Astro-Med®, Inc.

Astro-Med Industrial Park, West Warwick, Rhode Island 02893
Phone: (401) 828-4000 • Toll-Free (800) 343-4039 • Fax: (401) 822-2430
In Canada Telephone 1-800-565-2216

Sales and Service Centers throughout the U.S. and Canada

Astro-Med is system certified to ISO 9001

For More Information Write In No. 527

Lewis Research Center

In 1940, the US Congress authorized NASA's predecessor, the National Advisory Committee for Aeronautics (NACA), to build a facility solely for aircraft engine research. Named for the NACA's former director of aeronautical research, George W. Lewis, the Cleveland, Ohio-based laboratory sponsored valve research for radial engines–the war's workhorses–a cooling system for the B-29, fuels, lubricants, and seals. The center went on to develop liquid hydrogen propellant and the Centaur upper-stage launch vehicle for the space program, enabling Apollo astronauts to reach the moon. Lewis' chemical propulsion, seal design, and engine bearings research contributed to the space shuttle's main engines.

As NASA's lead center and Center of Excellence in aeropropulsion, Lewis conducts research and technology development in subsonic, supersonic, hypersonic, and high-performance aircraft propulsion systems, supported by research in materials, structures, internal fluid mechanics, instrumentation and control, interdisciplinary technologies, and aircraft icing. For next-generation, high-speed civil transport–which must improve upon current supersonic jets for fuel-efficiency and environmental considerations–Lewis is collaborating with General Electric and Pratt & Whitney to devise new enabling propulsion materials. Ceramics matrix composites, a major thrust of Lewis' materials research, could operate uncooled in the engine's extremely high-temperature, low-emission combustors.

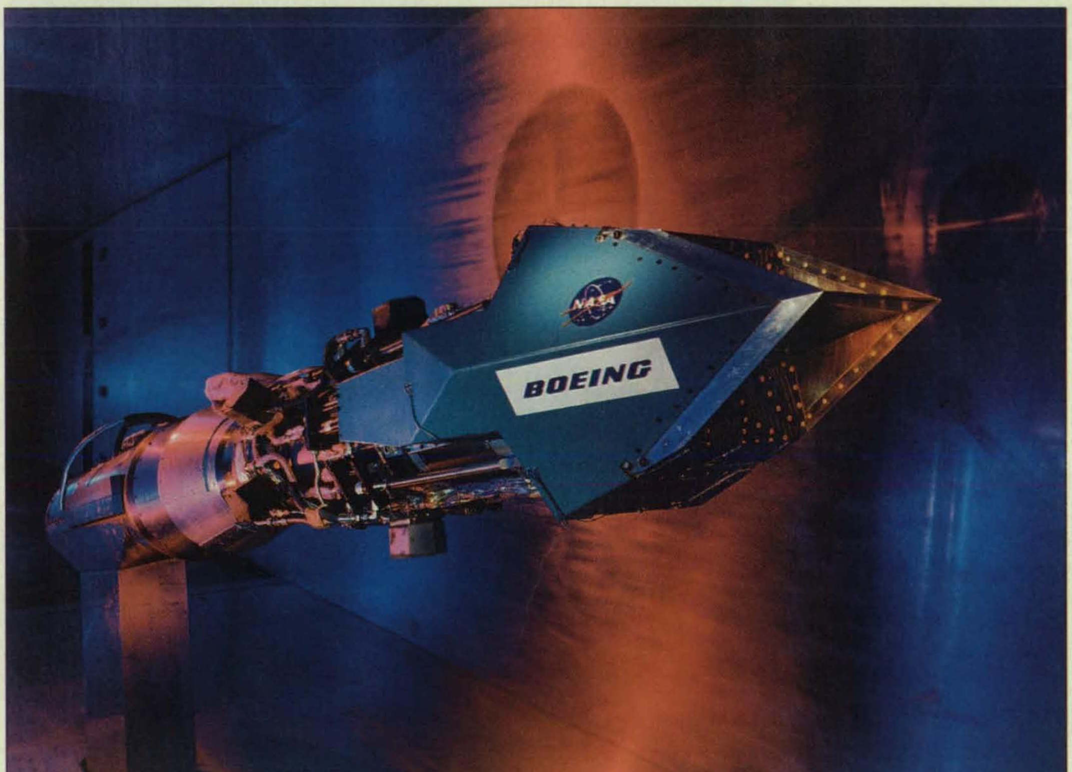
In satellite communications, another Lewis specialty, the center manages the Advanced Communications Technology Satellite (ACTS) project, essentially an orbiting technology laboratory, to meet increasing communications demands. ACTS is testing wide bandwidth channels and the Ka frequency band to compensate for the already congested C and Ku bands; spacecraft antennas that generate narrow spot beams; and a digital communications processor that routes traffic from the hopping spot-beams to the appropriate destination.

As with the ACTS program, Lewis focuses many of its projects to benefit the users in industry and academia who work with the center during development. Already, from ACTS, Motorola is adapting Ka-band and onboard switching technologies to its worldwide communications system, and Norris Communications is constructing a Ka-band spot-beam satellite.

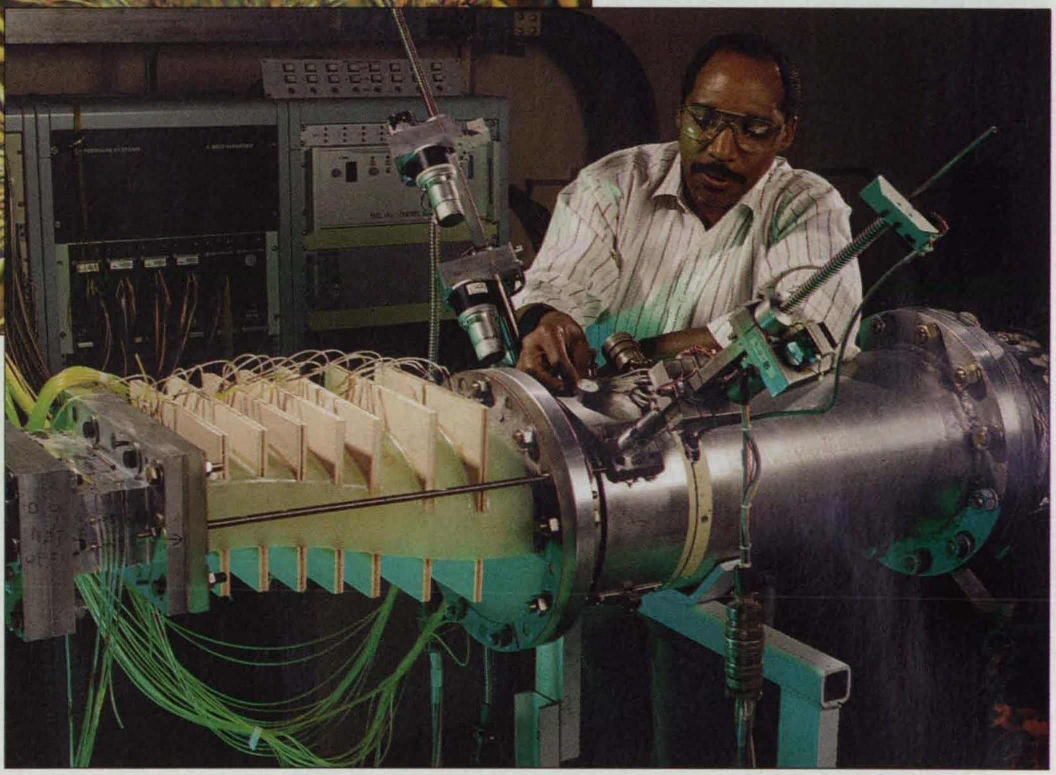
Facilities

Over 4000 personnel at Lewis' 350-acre Cleveland site and 6400-acre Plum Brook site carry out its aeronautical and related programs in 24 major facilities and over 500 specialized research facilities. The Icing Research Tunnel, the world's largest, was established in 1944 and led to the development of ice protection technologies that largely have diminished icing problems for aircraft, although research in improvements continues at the tunnel. The Hypersonic Wind Tunnel, the only nonvitiated hypersonic tunnel in the US, produces high mass-flow rates of high-temperature, uncontaminated air for simulating Mach 5 through Mach 7 velocities. Lewis also has 10 x 10-foot supersonic, 8 x 6-foot supersonic/transonic, and 9 x 15-foot subsonic wind tunnels; a propulsion systems laboratory; an engine component research laboratory; and a powered lift research laboratory.

Lewis' research in spacecraft power is carried out in facilities such as the Energy Conversion Laboratory, where new photovoltaic technologies are created.



Boeing's inlet concept for high-speed civil transport is tested at Lewis' 10 x 10 wind tunnel.



(Left) Metallograph, 500 times actual size, reveals the structure of a nickel aluminide eutectic alloy used in aircraft turbine blades, as developed through Lewis materials research. (Below) At Lewis' Engine Research Branch, Test Installations Division, a high-speed research duct model undergoes testing.

The Space Power Research Laboratory develops electrochemical power systems such as lightweight nickel-hydrogen batteries and hydrogen-oxygen fuel cells.

Lewis' Materials Division furthers innovations in ceramics, tribology, polymer matrix composites, and ceramic and metallic coatings. The new Microgravity Materials Science Laboratory offers access to academic, industry, and government researchers to conduct low-gravity materials processing experiments on the shuttle and in the future of the space station. To test the reliability and life of ceramic structures, researchers in Lewis' Structures Division wrote CARES, which won the 1994 NASA Software of the Year award (*NASA Tech Briefs*, December 1994, p. 12).

The Business Community as Customers

Although aeronautics and aerospace forms the primary thrust of Lewis research, the center also offers technology applications to other fields. For example, the center reaches out to universities, hospitals, and industry to encourage technology transfers and collaborative projects, employing the center's facilities and expertise in fluid mechanics; surface modification; energy storage systems and thermal transport; materials development and structural design; and electronics, communication, and instrumentation.

"We were interested in areas that might have a very strong coupling with the immediate community (Cleveland), which is known for its premier medical facilities and research," said Ann Heyward, chief of Lewis' Office of Commercial Development (OCD). "We already had many people in the lab transferring technologies from aerospace to health and medical applications and decided that it made sense to try and integrate this under one umbrella."

Lewis has collaborated with the bioengineering community to produce biologically compatible coatings for implants; structural-modeling computer codes for orthopedic implants; computer-assisted, minimally invasive surgery; acousto-ultrasonic detectors for bone and muscle deterioration; fiber-optic sensors; noninvasive, miniaturized sensors; and improved wheelchair-batteries.

"Our ultimate goal is to solve our customer's problem," said Heyward. "That may involve taking a Lewis technology and looking for an application for it–a 'technology push' approach. We are also looking at 'market pull' factors–what things are important to our customers and where they are looking for technologies, and trying to make those matches

where we can." Lewis is compiling a directory of expertise to be available in the next few months, she explained, "so if customers know they need some expertise in a particular area, they can turn to it in this directory."

The OCD has streamlined some of the processes by which industry can link up with Lewis. For example, it has standardized language in drawing up Space Act Agreements. "By doing so, and making it available electronically, we cut the time to prepare and approve an agreement from a year to about a month," Heyward said. "In one directorate alone, we've had a tenfold increase in the number of agreements in the last two years."

Lewis now has over 500 cooperative relationships of various kinds and leads the NASA field centers in the number of Small Business Innovation Research (SBIR) participants it manages.

Successful Transfers

This emphasis on partnering has resulted in a prolific amount of spinoffs and other applications of Lewis technology. In 1994, Lewis selected two companies, Hitec Products, Inc. and HITEC Corp., to commercialize its advanced high-temperature resistance strain gauges. Critical to advanced gas turbine engines and hypersonic aerospace vehicles, the gauges can accurately measure static strain to temperatures of 800° C, compared to 400° C by other instruments. Hitec sold 75 gauges in one month, and HITEC received several requests for gauge installation. Gauge sales are projected at $3-5 million in the next four years.

Lewis is a Center of Excellence in microgravity science, researching combustion science and fluid physics. This has led to at least one potentially important spinoff for the health care industry: a medical diagnostic tool that is a fiber-optic, laser light-scattering probe for early detection of cataracts, cholestrolosis, and other systemic and eye diseases. (For more on this technology, see "NASA Innovations" beginning on page 20.)

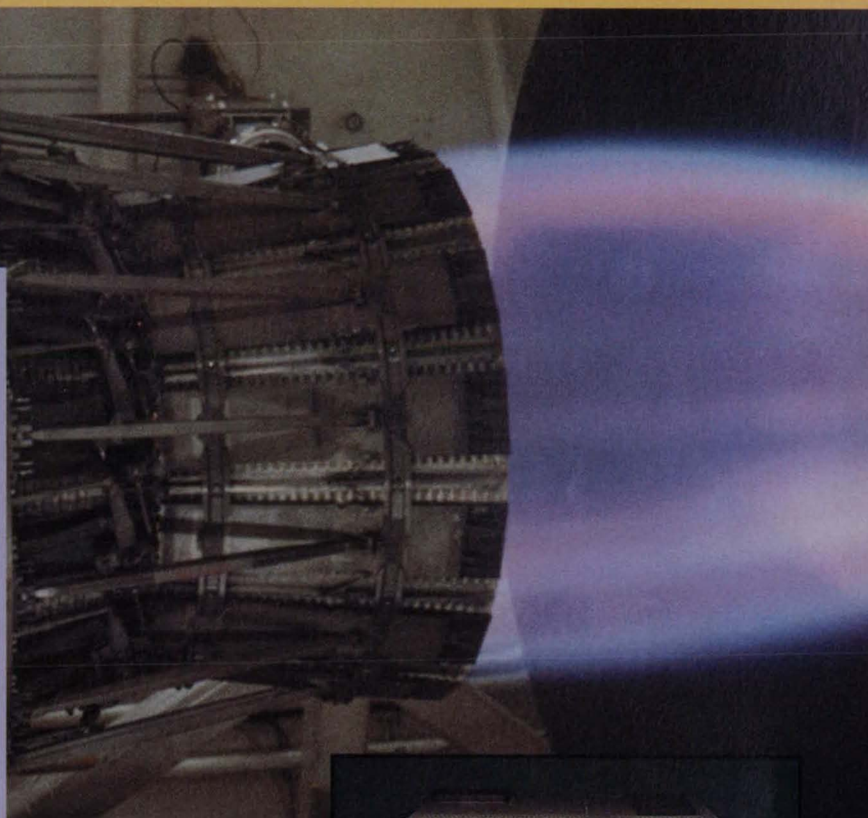
To increase the life of Allison Engine Co.'s Model 250 helicopter and rotary-wing aircraft turbine engine, Lewis and the company signed an Aerospace Industry Technology Program cooperative agreement with Howmet Corp., Cannon-Muskegon Corp., and Purdue University last January. By integrating new materials into the turbine wheel–doubling to tripling wheel life–and other components, the effort aims to maintain Allison Engine's US market share against increasing foreign competition. On top of NASA's $1.9 million cost share to the project, its partners contributed $4.4 million.

Other commercialized Lewis technologies include thin-film diamond-like carbon (DLC) used in scratch-resistant coatings for eyeglasses, wear-resistant hip-joint balls, and coatings for surgical needles to minimize needle-puncture damage to the patient and reduce recovery time. Research in ion propulsion for spacecraft has filtered into the development of industrial ion-beam sources, used for etching electronic microcircuits and depositing thin films for solar cells or optical equipment–or depositing DLC. When the center was hunting for a way to feed fuel into a weightless orbiting spacecraft's engine, it devised a magnetized fluid with finely ground iron oxide particles. This gave birth to Ferrofluidics Corp. of Nashua, NH, which found that a ferrofluidic rotary shaft seal solved a contamination problem in a system for making semiconductor chips. Now the use of ferrofluids in rotary shaft seals of all kinds has increased, and most computer memory disk drives use magnetic fluids.

For further information, contact Ann Heyward, Office of Commercial Development, Lewis Research Center, Cleveland, OH 44135; Tel: 216-433-3494; Fax: 216-433-5266; E-mail: caann@lims01.lerc.nasa.gov.

PSI.

Next Generation Turbine/Wind Tunnel Testing...Now!



Getting your aerospace test facility ready for the 21st century means looking to the innovators in pressure instrumentation. Electronic pressure scanning systems from Pressure Systems, Inc. changed the way the aerospace world measured pressure, and they remain the overwhelming standard in propulsion and wind tunnel testing.

Now, PSI is introducing the next generation of test equipment incorporating intelligent pressure scanners that provide digital compensation of sensor characteristics, including temperature effects. This virtually eliminates thermal error and provides guaranteed system uncertainty of less than ±0.05% FS.

And, PSI has dramatically enhanced the throughput of its VME-based System 8400 pressure scanning system with a new high performance hardware/software package that is also available for existing systems in the field. This enhancement provides the platform for significant system upgrades for years to come.

When you're getting your test facility ready for tomorrow, don't use yesterday's technology. Call Pressure Systems, Inc. today.

PRESSURE SYSTEMS

34 Research Drive
Hampton, VA 23666
1-800-678-SCAN
Fax: 804-766-2644

Photo courtesy of Arnold Engineering Development Center

For More Information Write In No. 518

Magnetic or Optical Surface Layer Would Indicate Strain

The surface layer would be deformed along with the substrate.

Langley Research Center, Hampton, Virginia

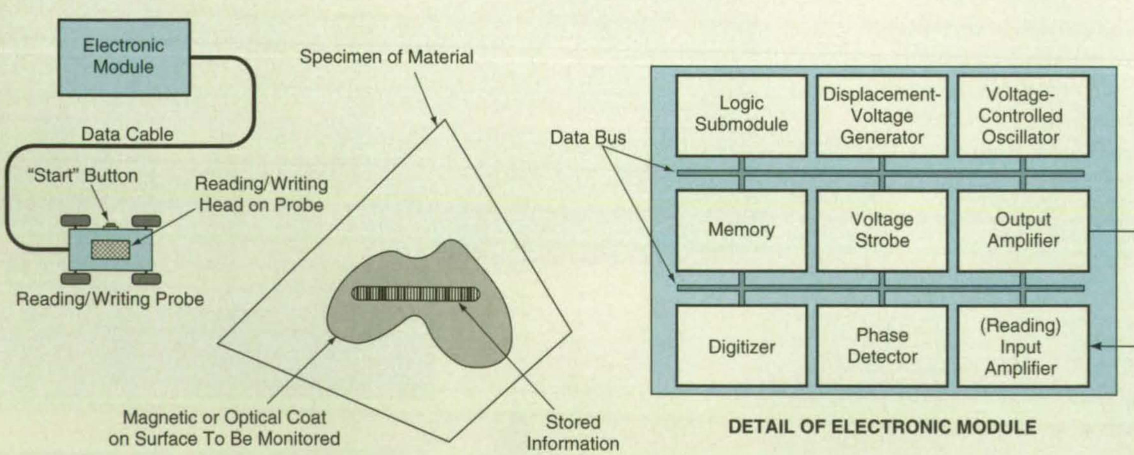
In a proposed method of obtaining information on strain at a surface of a material specimen, a magnetic coat (like that on magnetic tape) or an optical coat (like that on a compact disk) would be applied to all or part of the surface to be monitored. The coat would contain a record of its initial geometrical condition and would be read to determine changes in its condition, which changes would correspond to changes in the monitored surface.

The coating layer and the associated measuring equipment, taken together, would constitute a system called a "material strain monitor" (MSM). The system (see figure) would include an electronic module connected to a reading/writing probe via a data cable. The reading/writing probe would include wheels or other means of determining displacement of the probe along the surface. The probe would also include a reading/writing head, which would read and write information in the coating layer. A technician would press a "start" button on the probe to initiate the strain-monitoring procedure. The probe would then move over the surface to be monitored, writing or reading information in the coating layer.

In coating the surface to be monitored, magnetic particles could be mixed with a bonding agent and the mixture could be applied to the surface as a paint or spray. The resulting thin surface film would resemble the coating layer on a magnetic recording tape. The reading/writing probe used with such a film would be a standard magnetic reading/writing head capable of aligning the random magnetic domains in the film.

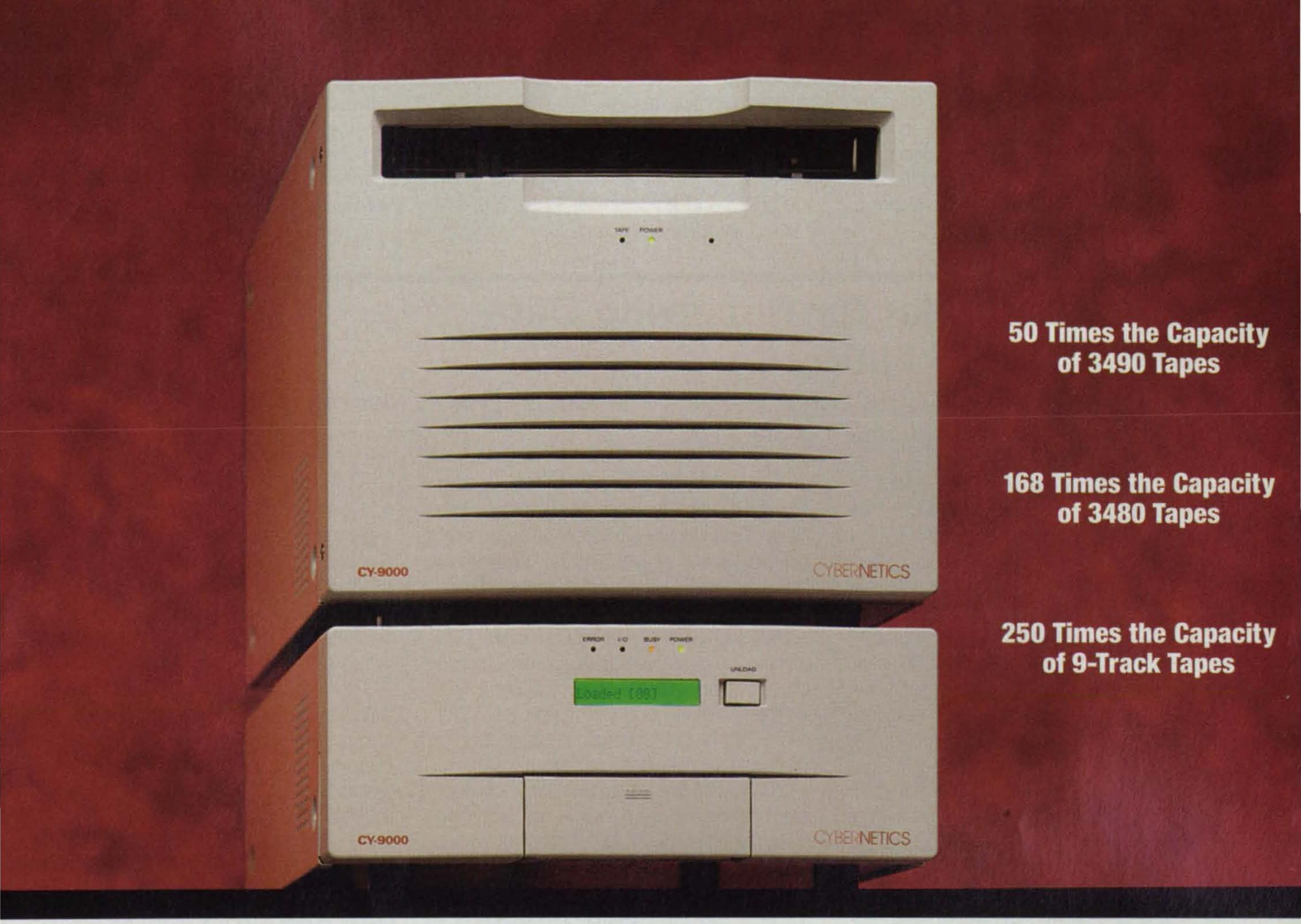
Alternatively, the coating layer could be a photographic emulsion applied in the dark. In this case, the reading/writing head could be connected to the electronic module via a fiber-optic cable and would include a lens to focus light onto the photographically treated surface. The fiber-optic cable could be used to both write in (expose) the emulsion and read from (measure the reflectance of) the emulsion.

The electronic module would include a logic submodule, a data bus, and a displacement-voltage generator, which together would measure the motion of the reading/writing probe over the monitored surface by use of rate-of-change-of-voltage (dV/dt) processing: The output of the displacement-voltage generator would govern the rate of generation of pulses by a voltage-controlled oscillator. These pulses would drive an output amplifier that would be connected to the reading/writing probe during writing. During reading, an input amplifier would be connected to the reading/writing head and a phase detector would compare the phase of the input (reading) signal with the phase of the signal from the displacement-voltage generator. The output of the phase detector would be digitized and stored in memory along with the position calculated by the logic submodule, which would integrate the signal from the displacement-voltage



A **Pattern of Information** would be stored magnetically or optically in the coating. Deformation of this pattern would provide data on the deformation of the underlying material. The electronic module would process the stored information.

42 GB At 12 MB Per Second.



The CY-9000 1/2" digital tape drive gives you fifty times the capacity and four times the speed of 3490 drives—with a much lower cost per megabyte. Writing data at 12 MB per second, it can store 42 GB in less than an hour. With a 32 MB data buffer, it's the perfect match for the fastest host computer systems running the most demanding storage and data collection applications.

Based on field-proven helical scan recording, the CY-9000 brings capacity and speed together like no other solution. With a MTBF of 200,000 hours and a bit error specification of less than one in 10^{17} bits read, reliability and data integrity are also unsurpassed.

True Compatibility With:

Alliant	HP	Prime
Altos	IBM	Pyramid
Apollo	ICL	Sequent
Arix	Intergraph	Silicon Graphics
AT&T	Macintosh	STC
Basic-4	McDonnell Douglas	Sun
Concurrent	Motorola	Texas Instruments
Convergent	NCR	Unisys
Convex	Parallel Port	Ultimate
Cray	PC	Wang
Data General	Pertec	*— and more*
DEC	Plexus	
Gould/Encore		

The CY-9000 can read and write both 42 GB and 12 GB cartridges, and automatically adjusts for the cartridge in use. A backlit display provides complete status information.

Backed by a one year warranty and the service and technical support of our in-house engineering teams, the CY-9000 is the high speed data storage solution you've been waiting for.

Call today for more information at

(804) 833-9000

CYBERNETICS

Tera One • Yorktown, VA 23693 • Fax (804) 833-9300

For More Information Write In No. 603

generator to calculate the distance (measured via rotation of the wheels) traveled along the surface.

Information would be written into the surface layer prior to deformation. The information pattern would remain embedded in the material and would suffer the same deformation as that of the material. Therefore, it would provide quantitative data on plastic deformation of the material. The data could be vectorized by writing the information in orthogonal tracks. Inasmuch as magnetic or optical lines can be read at densities of more than 10^5/in. (about 4×10^4/cm), the MSM could measure plastic deformations at high data densities anywhere a surface could be suitably coated. In contrast, conventional strain gauges can measure at single locations only, are vulnerable to mechanical disturbances, and cannot achieve high densities of data. The MSM will likely be very important in research in materials and mechanics; in particular, it is expected to compete strongly with systems based on image-analysis and laser techniques now being developed to obtain information on strain fields.

This work was done by Joseph S. Heyman of **Langley Research Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center; (804) 864-9260. Refer to LAR-14510.

Media Controller for Receiving Data From a TAXI™ Link

This circuit buffers data signals and detects some abnormalities in the signals.

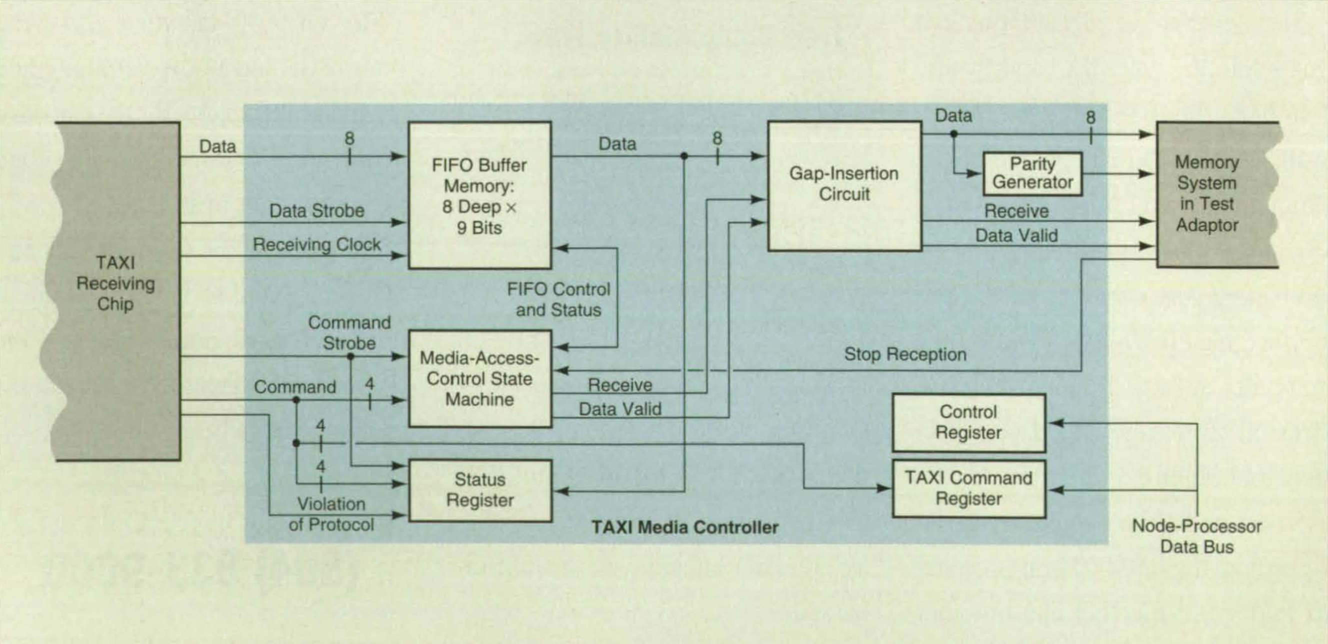
Lyndon B. Johnson Space Center, Houston, Texas

The TAXI™* media controller (TMC) is an interface circuit that supports the operation of test equipment in diagnosis of a telemetry system in which data are communicated via TAXI™ links. The TMC is designed specifically for use with a TAXI™ test adapter for monitoring and testing telemetry data signals generated by payloads and other subsystems of the Space Station Freedom. The TMC can also be used with other data-communication test equipment for testing TAXI™ links or other links that generate signals according to the same protocols.

"TAXI" as used here means "transparent asynchronous xmitter/receiver interface" (using "xmitter" for "transmitter" as is occasionally done in the electronics industry). A unidirectional high-speed serial data link can be constructed with TAXI™ transmitting and receiving integrated-circuit chips: At the source of data, a TAXI™ transmitting chip implements a 4-bit/5-bit coding scheme for serial transmission in which extra bits (beyond those needed to communicate data) are added for command symbols. At the receiving end of the link, a TAXI™ receiving chip decodes the signal and deserializes the data stream.

The test equipment in the original application is required to receive the data output of the TAXI™ receiver, verify the applicable data-packet protocol, and verify that the data rate does not exceed the data-buffering capabilities of the high-rate frame multiplexer which is used to receive the telemetry in the real system. The TMC helps the test adapter to perform these functions. Overall, the TMC can be characterized as providing an interface between the output port of a TAXI™ receiving chip and the input port of a memory system in the test adapter (see figure).

The output of the TAXI™ receiving chip consists of decoded parallel data and command symbols, which could, in principle, be clocked into compatible test-adapter logic circuits by use of a receiving clock signal derived from the serial data signal. However, because the phase and frequency of this clock signal vary with the data stream, this clock signal is not suitable for clocking logic circuits in the test adapter that



The **TAXI™ Media Controller** detects some abnormalities in the received data stream and resynchronizes the stream to a locally generated clock signal.

Just because

we make HP plotters so reliable doesn't mean we can't surprise you once in a while.

Now starting at

$2,395

HP DesignJet plotters are well known for their crisp, clean print quality. Are noted for their impressive speed. And, of course, are consistently applauded for their reliability, backed by a next-day, on-site service warranty. Now, with two new models, we bring you affordability. The HP DesignJet 230 offers D-size monochrome plotting for only $2,395. And for $2,995, the HP DesignJet 250C finally puts color plotting within reach.* For an output sample or the name of your local HP demo dealer, visit us on the World Wide Web at http://www.hp.com/info/9552.

Or, call 1-800-851-1170, Ext. 9552.†

*U.S. list prices. HP DesignJet 230 E-size model priced at $3,195. HP DesignJet 250C E-size model priced at $3,995. Price does not include optional legs. Plot designed by Miriello Grafico, Inc. †In Canada, call 1-800-387-3867, Ext. 9456. PE12554

HEWLETT® PACKARD

For More Information Write In No. 502

depend on steady clock signals. Therefore the TMC performs the initial clocking in of the data signal, stores the data in a first-in/first-out (FIFO) buffer memory, and resynchronizes the stored data by transferring them from the FIFO buffer memory to the memory in the test adapter under control of a steady local clock.

As an integral part of the resynchronization and readout from the FIFO buffer memory, the TMC inserts gaps between packets of data that have been received too close together for the memory system in the test adapter to manage without loss of data. When command symbols in the data stream are used to implement a low-level protocol (for example, encapsulating packets of data between "start" and "stop" delimiters), there is also a need for a media-access-control state machine to detect these protocol elements and respond accordingly. The TMC includes such a state machine, which supports two low-level protocols used in the original application. The TMC includes logic circuits and a status register for detection of three abnormal phenomena; data packets without end delimiters, data packets received too close together, and command symbols not defined by the low-level protocol.

* "TAXI" is a registered trademark of Advanced Micro Devices, Inc.

This work was done by David R. Stauffer and Rebecca Stempski McMahon of International Business Machines, Inc., for **Johnson Space Center**. *For further information,* ***write in 6*** *on the TSP Request Card. MSC-22418*

Data-Logger Interface and Test Controller

Marshall Space Flight Center, Alabama

A data-logger interface and test controller (hereafter "the controller" for short) has been developed to enable the automation of tests in conjunction with data-acquisition functions performed by data loggers that have output-switching capabilities. The controller includes relay logic circuits that remain deenergized until an out-of-tolerance condition on any data channel is discovered. The controller is designed to be connected to a Fluke model 2286A (or equivalent) data-logger system, which features 3 control channels with 6 data inputs per channel. The controller includes an elapsed-time counter that keeps track of power outages.

This work was done by Donnie R. Burch for **Marshall Space Flight Center.** *For further information,* ***write in 84*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-28978.

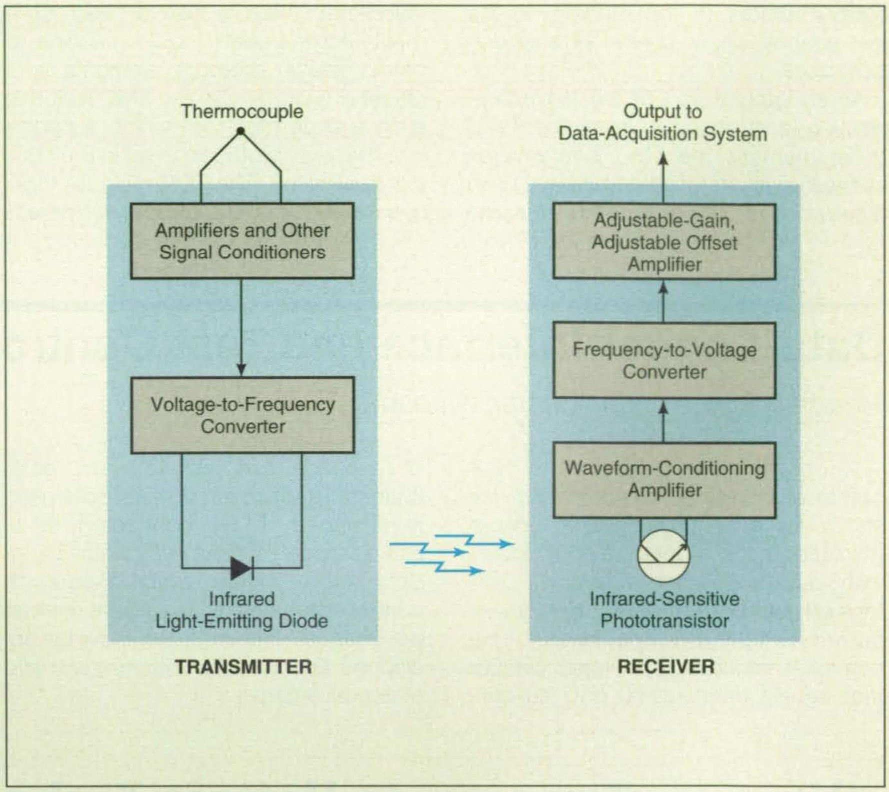
Wireless Infrared Data Link

The rate of repetition of infrared pulses indicates a measured physical quantity.

Lyndon B. Johnson Space Center, Houston, Texas

An infrared transmitter and receiver have been designed for wireless transmission of information on a measured physical quantity (for example, temperature) from a transducer device to a remote-acquisition system. In the transmitter, the output of a transducer (in this example, a thermocouple) is amplified and shifted with respect to a bias or reference level, then fed to a voltage-to-frequency converter to control the frequency of repetition of current pulses applied to an infrared-light-emitting diode. In the receiver, the frequency of repetition of the pulses is converted back into a voltage indicative of the temperature or other measured quantity. This voltage is fed to the data-acquisition system.

In the original temperature-measurement application, the transducer is a type-T thermocouple. In the transmitter, the voltage output of the thermocouple is amplified, shifted with respect to a bias or reference level, and fed to a voltage-to-frequency converter to control the frequency of repetition of pulses applied to an infrared-light-emitting diode that radiates at a wavelength of 880 nm. The frequency is 3.6 kHz at a temperature of 20°C and changes with temperature at a rate of 5.1 Hz/°C. The temperature resolution of the transmitter is about 0.1 °C.



The **Frequency of Repetition of Infrared Pulses** is varied according to a measured physical parameter; in this case, temperature as sensed by the thermocouple. The receiver converts the pulse-repetition frequency back to a voltage, which is thus indicative of the sensed temperature.

An infrared-sensitive phototransistor in the receiver detects the modulated infrared signal. The electrical output of the phototransistor is processed by a waveform-conditioning amplifier, then by a frequency-to-voltage converter, then by an adjustable-gain, adjustable-offset amplifier. The final output voltage of the receiver varies with the thermocouple reading at a rate of 26 mV/°C; at this rate, the increment of voltage that corresponds to the temperature resolution of the transmitter (2.6 mV per 0.1 °C) matches the voltage resolution of most commercial data-acquisition systems.

The transmitter and receiver are small and light in weight, and they consume little power. Modified versions with suitable coding of signals could be used to transmit multiple measurements. Potential applications include logging data while drilling for oil, transmitting measurements from rotors in machines without using slip rings, remote monitoring of temperatures and pressures in hazardous locations, and remote continuous monitoring of temperatures and blood pressures in medical patients, who could thus remain mobile.

This work was done by Timothy E. Roth of Allied Signal Technical Services Corp. for **Johnson Space Center**. *For further information,* ***write in 87*** *on the TSP Request Card. MSC-22567*

Neural Networks Analyze Data in Particle-Impact-Noise Tests

Interpretation of test data is more objective and accurate.

Lewis Research Center, Cleveland, Ohio

Electronic neural networks and computers have been put to use in analyzing data acquired in particle-impact-noise-detection (PIND) tests of packaged electronic components. PIND tests are performed to detect loose particles in the packages that could cause failures during subsequent operation of the packages in the presence of accelerations or other effects — for example, loose electrically conductive particles that could bounce into positions in which they would cause short circuits.

A PIND test is an instrumented and systematic version of the intuitive "shake-and-rattle" test. In a PIND test, the part in question is vibrated in a controlled manner by use of a shaker,

Our data acquisition boards perform amazing feats from Windows, too.

Data acquisition boards. High performance. Windows. Now, you can get all three in a single bound. Thanks to Keithley MetraByte. Let's just say our family of boards exceeds those of mere mortal manufacturers.

For example, our DAS-4300 is the fastest PC-based digitizer in the world today, with a sample speed of 1 GHz. It's part of our DAS-4000 Series that captures high-speed waveforms, even under Windows. The series is supported by VisualSCOPE software and Keithley MetraByte's VTX™ custom controls for Microsoft's Visual Basic. For speed and accuracy across up to 256 channels, our DAS-1800 Series boards are unmatched. They give you the ability to expand channels, and change gains and channel order while maintaining high accuracy. The DAS-1800 Series supports a wide range of signal and sensor options, and is available with either 12- or 16-bit resolution. And they are also supported by VTX.

For more information on our entire line of high-performance data acquisition products, call Keithley MetraByte today at 1-800-903-1294. And see how super our products really are.

KEITHLEY METRABYTE

Keithley MetraByte, 440 Myles Standish Blvd., Taunton, MA 02780. Tel 800-903-1294. Fax 508-880-0179
Internet: http://www.metrabyte.com Spec Direct™ faxback: 800-636-3377

DAS-4000 Series

True sampling up to 1 GHz: the fastest data acquisition board in the world.

DAS-1800 Series

Accurately acquires at 312 ksamples/s on up to 256 channels using only 1 PC slot.

DAS-1802HR

16-bit resolution and guaranteed accuracy of 0.001% +/- 1.5 LSB while maintaining 100 ksamples/s.

DAS-1800AO

Simultaneous stimulus and response with waveform outputs at up to 500 ksamples/s.

VisualSCOPE and DAS-4000 Series

Turns your PC into a powerful oscilloscope.

V T X COMPATIBLE

The DAS-4000 and DAS-1800 Series are supported by Keithley MetraByte's VTX for Visual Basic™—graphical custom controls for data acquisition under Windows.™

KEITHLEY METRABYTE ISO 9001 CERTIFIED

For More Information Write In No. 602

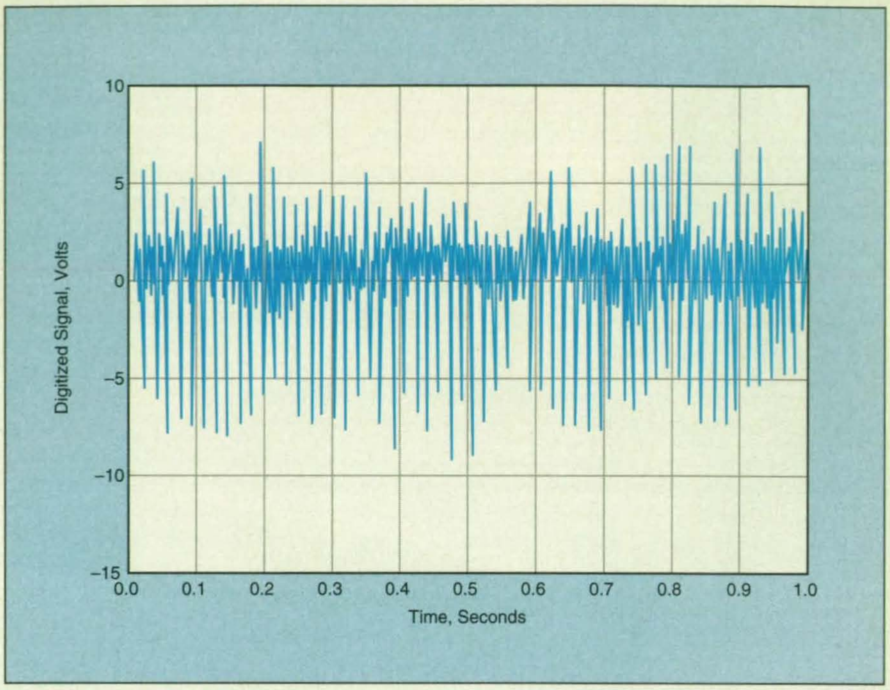
while a microphone picks up the noise emitted by the shaken part. The output of the microphone is recorded, yielding a history of noise that is subsequently analyzed.

Previously, data from PIND tests were analyzed in a labor-intensive and error-prone process of subjective human interpretation. The average accuracy of such interpretation has been found to be about 44 percent. Accordingly, the neural-network computerized method was introduced to automate the analysis and to increase its accuracy by reducing human subjectivity and error.

In this method, the recorded noise signal is first processed by a computer-controlled analog-to-digital converter. The digitized noise-signal data (see figure) are then processed into voltage data bins, the contents of which serve as inputs to a neural network. The neural network then analyzes the data, deciding whether or not the tested package contained loose particles.

Neural networks of both the back-propagation and the self-organizing-map types have been successfully trained and tested on PIND data. Preliminary results suggest that the use of neural networks will result in significant improvement in the quality and reliability and decrease in the cost of PIND testing.

This work was done by Lois J. Scaglione of **Lewis Research Center**. *For further information,* **write in 65** *on the TSP Request Card. LEW-16077*



This **Plot Shows a Digitized Noise Signal** from a one-second interval of a PIND test of an electronic part that contained loose particles.

ONE 4 ALL

DADiSP 4.0

With version 4.0, DADiSP, the popular engineering software tool, becomes the *one for all* your data analysis and signal processing needs. A powerful new programming language and dynamic new features make DADiSP 4.0 more robust and easier to use than ever, while retaining its unique ability to collect, analyze, and display data with the power and flexibility of a spreadsheet.

Added to the hundreds of existing analysis functions are:

- Native Microsoft Windows GUI
- X-Windows Motif GUI
- On-line Documentation
- On-line HELP
- Customizable Worksheet Configuration
- Customizable Toolbar Buttons
- SPL - Series Processing Language
- DDE - Dynamic Data Exchange
- Enhanced Report Graphics
- Print Preview Mode
- Variables

With DADiSP, you can construct sophisticated analysis chains in seconds. Load a new data series, matrix, signal, or image, alter a parameter, or select a new function, and all windows update automatically. DADiSP's icons, buttons, and menu-interface place data analysis under *your* control. Just *pick and click* and DADiSP displays your results *immediately*.

For a Free TRiAL
Telephone: **1-800-777-5151**
Internet: http://www.dadisp.com

DSP Development Corporation

One Kendall Square, Cambridge, MA 02139
617-577-1133, FAX: 617-577-8211

CCD/CID Processors Would Offer Greater Precision

Each cell would contain 1 bit of the binary representation of a matrix element.

NASA's Jet Propulsion Laboratory, Pasadena, California

Charge-coupled-device/charge-injection-device (CCD/CID) data processors of a proposed type would offer the advantages of massively parallel computational architecture and high computational speed typical of older CCD/CID data processors, but with increased precision. Typically, the precision of an older CCD/CID processor is limited to about 8 bits. The proposed devices could be made precise to an arbitrarily large number of bits. CCD/CID processors are especially useful in performing matrix•vector multiplications in a variety of applications, including solving partial differential equations, processing signal and image data, control computations, and neural-network simulations. The greater precision of the proposed devices could help to ensure accuracy in CCD/CID implementations of pseudospectral neural networks — a particular class of artificial neural networks that are especially well suited to solving nonlinear differential equations.

Figure 1 is a simplified schematic diagram of a typical older CCD/CID array. Each cell in the array is connected to an input column line and an output row line via a column gate and a row gate, respectively. These gates acting together hold, in a silicon substrate underneath them, a charge that represents an analog matrix element. In a default mode of operation, the matrix charges sit under the column gates.

In the basic matrix•vector multiplication mode of operation, with a binary input vector, the column gates serve as binary•analog multipliers by transferring the matrix charges toward the row gates only where the input bits of the columns indicate binary "ones." The charge transferred under the row gates is summed capacitively on the output line of each row, yielding an analog output vector that is the product of the binary input vector with the analog charge matrix. By virtue of the principle of operation of the CCD, the charges are sensed nondestructively, and the charge matrix is restored to its original state simply by pushing the charges back under the column gates.

A bit-serial digital•analog matrix•vector multiplication can be obtained from a sequence of binary•analog matrix•vector multiplications, by feeding in vector input bits sequentially, and adding the corresponding output contributions after scaling them with the appropriate powers of 2. A simple parallel array of divide-by-2 circuits at the output accomplishes this task. Further extensions of the basic matrix•vector multiplication scheme support full digi-

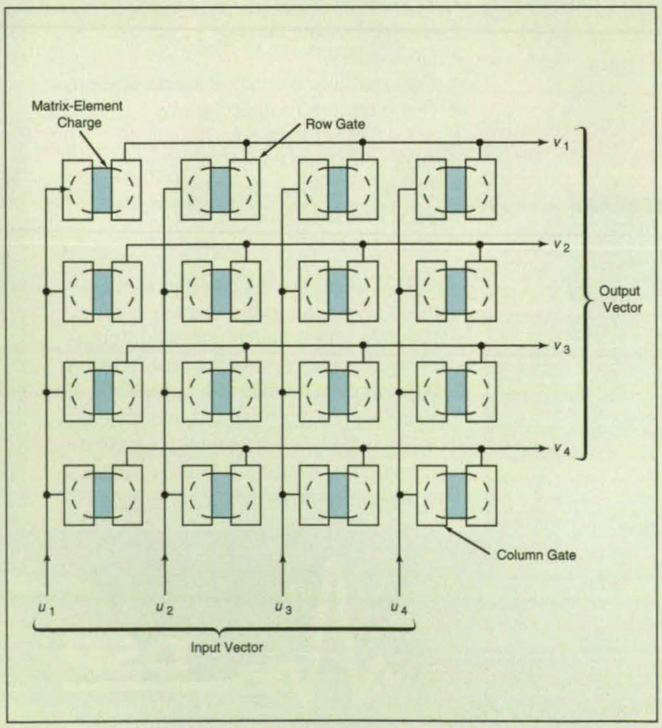


Figure 1. A **CCD/CID Data Processor** contains CCD cells tied together by row and column electrodes. Matrix elements are represented by packets of electric charge. Computation involves transfers of charges from column gates to row gates.

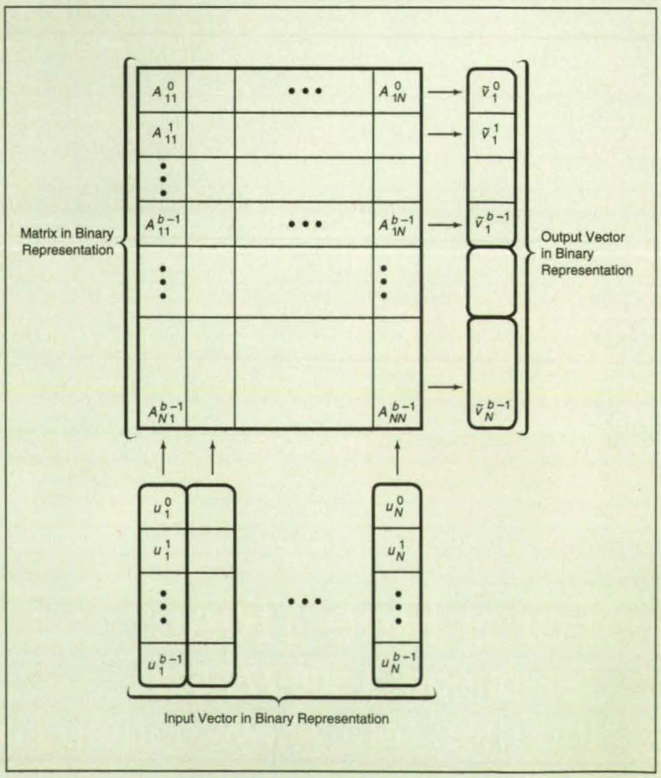


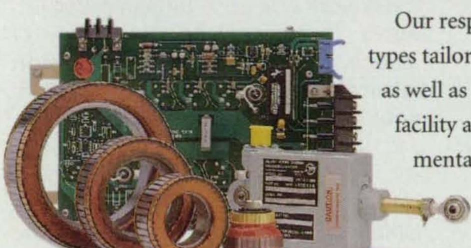
Figure 2. This **Improved CCD/CID Layout** would enable matrix•vector computations with precision of b bits.

He knows the value of a reliable system. So does Kollmorgen Inland Motor.

When you are in lower Earth orbit, the reliability of the systems around you is paramount. Kollmorgen Inland Motor offers space rated motion control hardware that meets your needs.

At Kollmorgen Inland Motor reliability is a critical design feature of your space rated motion control components. In every phase from design concept through manufacture and testing we carefully control our processes to ensure your motion control system performs to stringent standards.

Our experience in providing space qualified motors spans more than 30 years. We have provided hardware for space vehicles, ground stations, shuttles, telescopes, and satellites. Our impressive participation list includes Apollo, Gemini, Skylab, Titan, the Explorer Platform, Centaur, Global Positioning System (GPS) and many others. We meet your complete motion control needs by offering DC torque motors, brushless motors, motor drive and control electronics, and electromechanical actuators.



Our responsive engineering and manufacturing teams will work with you to quickly deliver prototypes tailored to your specific system requirements. We are skilled in the proper selection of materials as well as design and testing to meet stringent military and NASA standards. Our manufacturing facility and quality assurance system complies with MIL-Q-9858 and we can provide special documentation when required. Superior product support both before and after product delivery enables you to use our motion control systems in the most critical of applications with complete confidence.

For space rated motion control systems he can rely on. Kollmorgen Inland Motor.

KOLLMORGEN

Inland Motor

See Us at Technology 2005, Chicago, booth #827

501 First Street, Radford, VA 24141 800.753.6686 Tel/703.731.4193 Fax

For More Information Write In No. 571

tal outputs by parallel analog-to-digital conversion at the outputs, and four-quadrant operation by use of differential-circuit techniques.

The key innovation in the proposed CD/CID processors is to encode 1 bit of the binary representation of each matrix element in one cell. Thus, as shown in Figure 2, if a matrix **A** were to be specified with b bits of precision, an element A_{ij} would be located in cells

$$[b\,(i-1)+\ell, j], \text{ for } \ell = 1, \ldots b;$$

these bits would be denoted

$$A_{1}^{0}, \ldots A_{ij}^{b-1}$$

Thus, the price of increased precision would be increased size (each matrix element being spread over b rows). One added benefit would be a reduction in refresh time, inasmuch as each packet of charge would represent only a binary quantity.

Computation would proceed as follows: At clock cycle one, the matrix **A**, in its binary representation, would be multiplied by the binary vector

$$\left(u_1^0, \ldots u_N^0\right)$$

which would contain the least significant bits of vector $(u_1, \ldots u_N)$. By virtue of the charge-transfer mechanism, analog voltage

$${}^{(0)}\tilde{v}_i^0 \ldots {}^{(0)}\tilde{v}_N^{b-1}$$

would be sensed at the output end of each row. At clock cycle two, these voltages would be fed into a pipelined analog-to-digital converter having d bits of precision (where $d = \log_2 N$, and N denotes the number of columns of **A**), while simultaneously **A** would be multiplied by

$$\left(u_1^1, \ldots u_N^1\right)$$

[which would contain the next more significant bits of $(u_1, \ldots u_N)$], yielding ${}^{(1)}\mathbf{v}$.

At clock cycle three, the digital representations of

$${}^{(0)}\tilde{v}_i^0 \ldots {}^{(0)}\tilde{v}_N^{b-1}$$

would be bit-mapped into a register with an appropriate offset (in general, ℓk bits of offset at clock cycle k for element $\tilde{v}_j^l$), each offset pointer would be incremented by one, the voltages ${}^{(1)}\mathbf{v}$ would be fed into the analog-to-digital converter, and **A** would be multiplied by vector

$$\left(u_1^2, \ldots u_N^2\right)$$

to obtain ${}^{(2)}\mathbf{v}$. Elements

$${}^{(k)}\tilde{v}_j^l$$

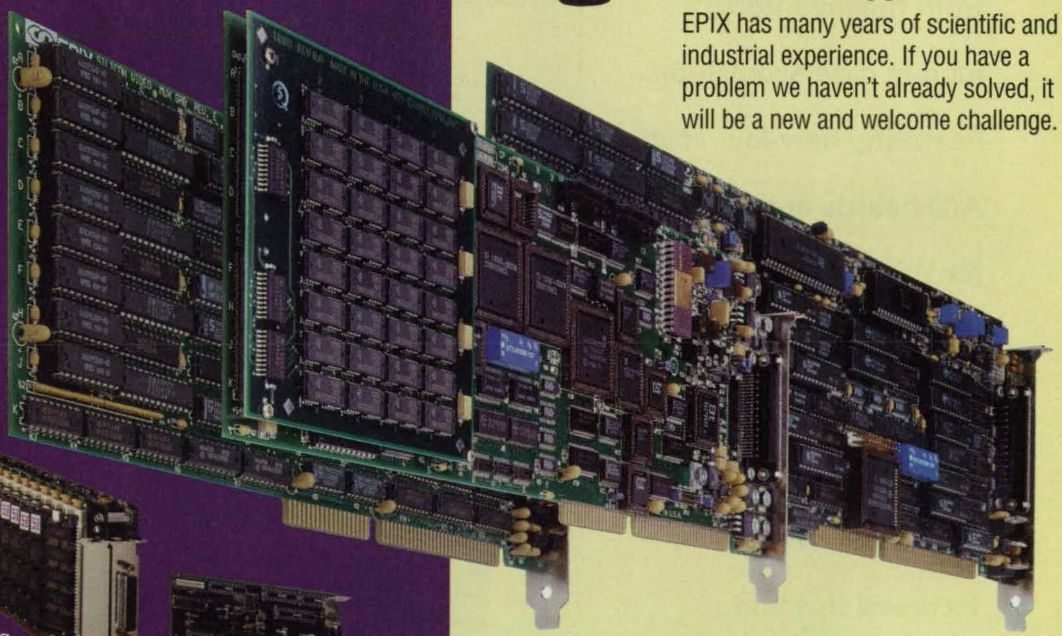
with same row index i would then be fed into cascaded sum circuits, in parallel for all i, pipelined over k. Thus, the components v_i of the product $\mathbf{v} = \mathbf{Au}$ would be obtained after $\log_2 b$ cycles, and the overall latency would be $b + \log_2 b + 3$. If one needed to multiply a set of vectors **u** by the same matrix **A**, this pipelined architecture would result in an output vector every clock cycle.

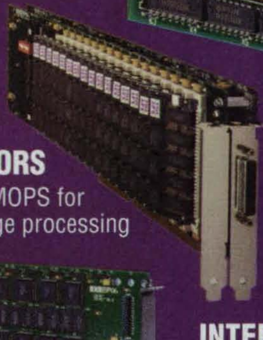
This work was done by Jacob Barhen, Nikzad Toomarian, and Amir Fijany of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 130*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

William T. Callaghan, Manager
Technology Commercialization
JPL-301-350
4800 Oak Grove Drive
Pasadena, CA 91109

Refer to NPO-18972 volume and number of this NASA Tech Briefs *issue, and the page number.*





Multi-Band Frequency-Selective Microwave Reflectors

Double-loop patch and slot elements are used in two different frequency-multiplexing designs.

NASA's Jet Propulsion Laboratory, Pasadena, California

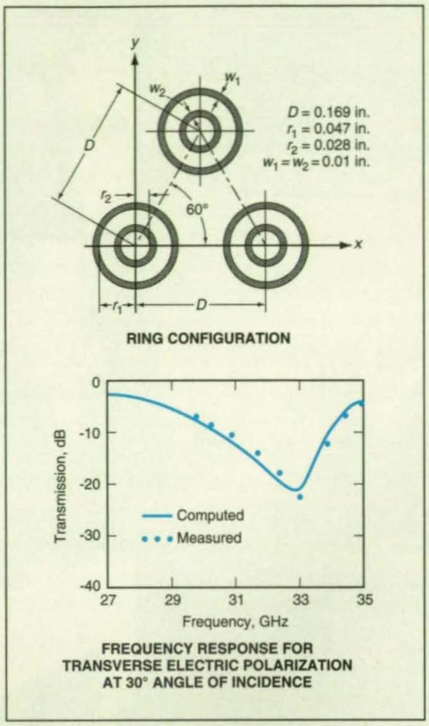


Figure 1. This **Array of Double-Round-Loop Conductive Patches** is highly reflective at frequencies around 33 GHz (in the K_a band).

Two different frequency-selective reflectors have been studied for use in multiplexing signals at selected frequencies in the S, X, K_u, and K_a frequency bands in a microwave communication system. One reflector is designed to be highly transmissive at frequencies of 2.3 GHz (in the S band) and 13.8 GHz (in the K_u band); at the same time, it is highly reflective at frequencies of 7.2 and 8.4 GHz (in the X band) and 32 and 34.5 GHz (in the K_a band). The other reflector is designed to be highly transmissive in the K_a band and highly reflective in the S, X, and K_u bands.

These frequency-selective reflectors are closely related to the ones described in several previous articles in *NASA Tech Briefs*, including "Frequency-Selective Microwave Reflectors" (NPO-18701), Vol. 18, No. 1, (January, 1994), page 32; "Improved Dichroic Microwave Reflector" (NPO-18664), Vol.19, No.8, (August, 1995), page 34; "Double-Square-Loop Dichroic Microwave Reflector" (NPO-18676), Vol. 18, No. 3, (March, 1994), page 38; "Triband Circular-Loop Dichroic Microwave Reflector" (NPO-18714), Vol. 18, No. 3, (March, 1994), page 41; "Making Curved Frequency-Selective Microwave Reflectors" (NPO-18755), Vol.19, No.8, (August, 1995), page 38; and "More Circular-Loop Dichroic Microwave Reflectors" (NPO-18940), Vol.19, No.1, (January, 1995), page 42.

The first-mentioned reflector is designed according to a double screen approach. The double screens were bonded to the front and back surfaces of a foam- or honeycomb-core dielectric

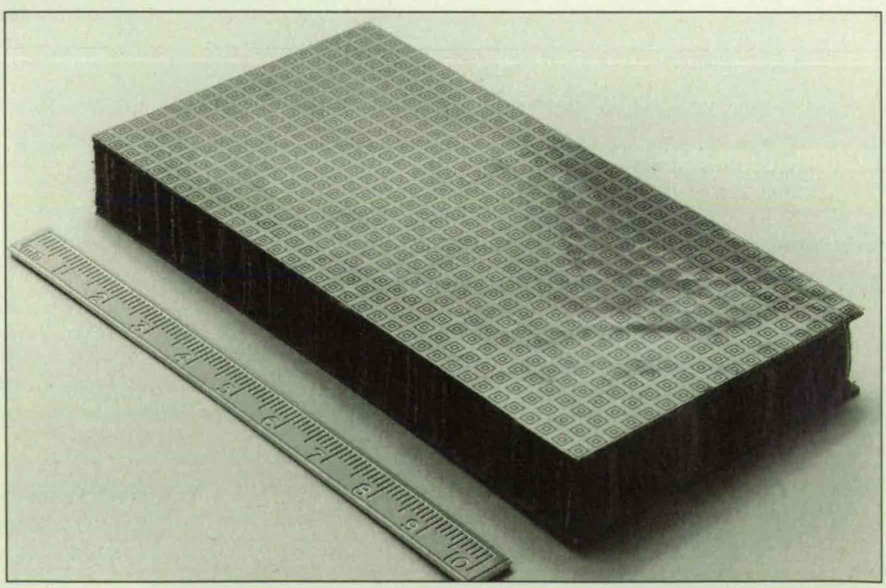
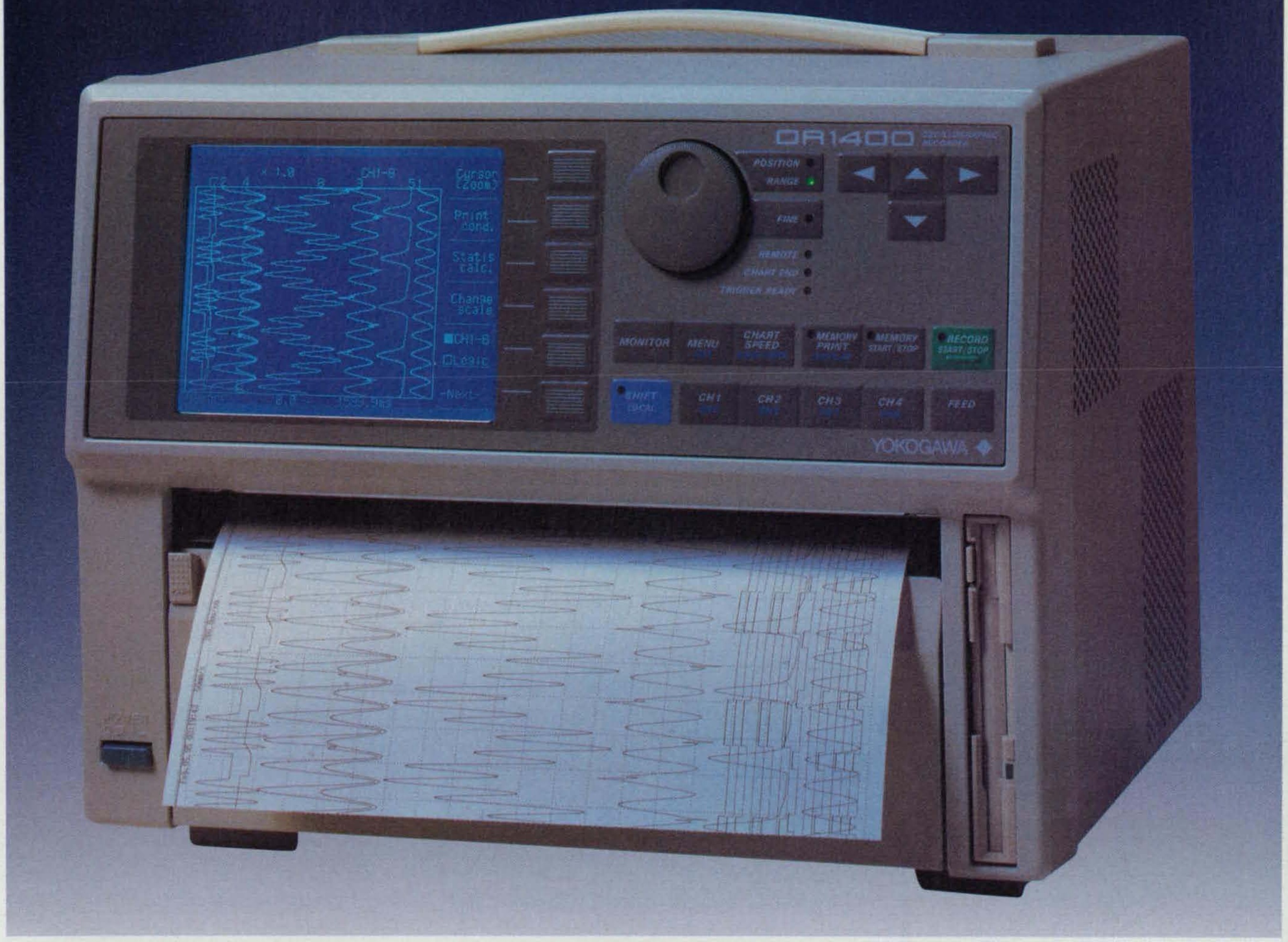


Figure 2. This **Array of Double-Square Loop Slots in a Conductive Plane** is highly transmissive in the S and K_u bands and highly reflective in the X band.

Unlike your VCR, with this RECORDER, you won't need a PhD to know how to capture the next big event.



Yokogawa introduces:

***True Technology Simplified*, the OR1400 Oscillographic Recorder.**

- Fast, High-Definition Real-Time recording at Chart Speeds up to 250 mm/sec.
- Capture that Big Event with sampling up to 100 KHz, 256 Kword/Ch. Memory and 3.5-inch. floppy disk drive
- Plug-in Architecture for flexible input signal handling: Voltage (DC, AC, RMS), Thermocouples, Strain, Frequency, TTL/Switch Closure
- Easy Operation through natural-language displays
- Compact, weighs only 18 lbs., and it's even available in a rack-mount version

For More Information fill in and fax to **404-251-2088**

Name: ____________________Phone:(   )___________

Company: _________________________________

Address:__________________________________

or call us at **800-258-2552**

Yokogawa Corporation of America, 2 Dart Rd., Newnan GA 30265

YOKOGAWA

Yokogawa Corporation of America

For More Information Write In No. 509

panel. In this case, the front surface consists of a K_a-band-reflective array of double-round-loop electrically conductive patches (see Figure 1) on a dielectric sheet of polyimide. The other surface is transmissive in the S and K_u bands and reflective in the X band.

The second-mentioned reflector is designed according to a single screen approach, in which only one surface of a dielectric panel supports a single array of antenna elements that provides the required frequency-selective characteristics. In this case, the array consists of double-square-loop slot elements etched into a metal film on a polyimide sheet (see Figure 2).

The two designs have been tested by computer simulation and in experiments. The measured and computed performances were found to be in fairly good agreement. The S-band loss was found to be significantly smaller in the second-mentioned design.

This work was done by Te-Kao Wu of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 165*** *on the TSP Request Card. NPO-19016*

Thin-Film Power Transformers

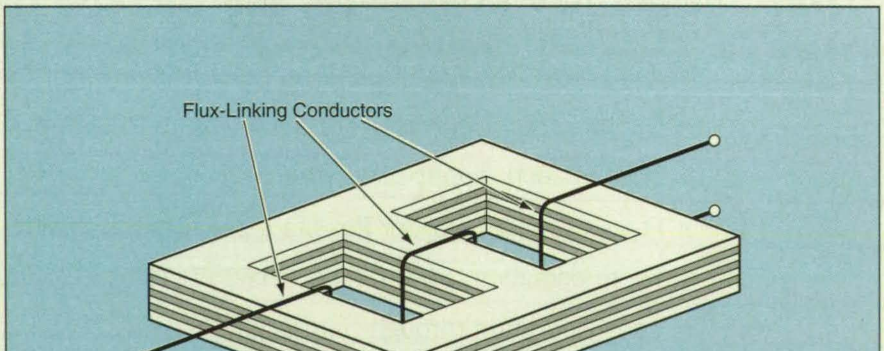
Layers of ferromagnetic, conductive, and insulating materials would be used.

NASA's Jet Propulsion Laboratory, Pasadena, California

Miniature power transformers would be made by thin-film microfabrication techniques, according to a proposal. The microstructures of these transformers would be built in multiple thin layers, which would typically consist, variously, of ferromagnetic, electrically conductive nonferromagnetic, and electrically insulating materials (see figure).

The proposed transformers could have geometric features finer than those of transformers made in the customary way by machining and mechanical pressing. In addition, some thin-film materials exhibit magnetic-flux-carrying capabilities superior to those of the customary bulk transformer materials. Taking advantage of the flexibility of design afforded by thin-film microfabrication techniques, one could choose the materials, shapes, thicknesses, and lateral dimensions of the thin layers to shape magnetic-flux paths, suppress eddy currents, obtain specified reluctances, and otherwise generally optimize designs and performance characteristics. Thin-film transformers might be suitable for low-cost, high-yield mass production.

This work was done by Romney R. Katti of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 94*** *on the TSP Request Card. NPO-19092*



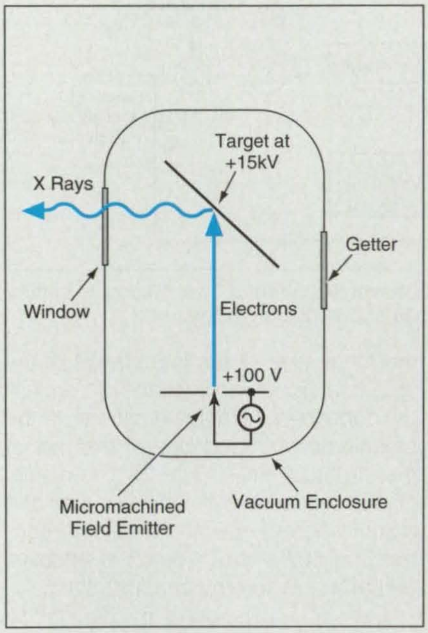
A **Transformer Core** would be made of thin layers of an insulating material interspersed with thin layers of a ferromagnetic material. Flux-linking conductors made of thinner nonferromagnetic-conductor/insulator multilayers could be wrapped around the core.

Miniature X-Ray Tubes

Micromachined field emitters would be used instead of thermionic emitters.

NASA's Jet Propulsion Laboratory, Pasadena, California

Miniature x-ray tubes have been proposed for use in portable instruments used to analyze minerals. Instead of the thermionic emitters (hot filaments or cathodes heated by hot filaments) of conventional x-ray tubes, micromachined field emitters (see figure) would serve as the sources of electrons in the proposed x-ray tubes. Filaments are subject to breakage, their lifetimes are limited, and they are sensitive to operation in vacuum and near-vacuum environments. Fabricated from silicon wafers, the micromachined field emitters (MFEs) would not be subject to breakage or restrictions on lifetimes, and can tolerate vacuums that filaments cannot. MFEs use low voltage ($\leq$ +100V) to obtain field emission across a micron-size gap. Thus, they are small and use little power.



Electrons From a Field Emitter (instead of a thermionic emitter) would be accelerated to a target to generate x-rays.

The miniature x-ray tubes would be very robust, immune to shock and vibration, and could be permanently sealed with a getter for continued pumping. They could be combined with solid-state x-ray detectors for analysis of x-ray fluorescence. For protective redundancy, a single tube could contain an array of field emitters. Because of the smallness of the field emitters ($\approx$ 1µm), the x-ray tubes could be made quite small. Very little power would be needed to cause emission of electrons, and the tubes could be operated in a flash mode, so that the overall power demand of such a tube would be so low that it could be satisfied by a trickle-charged battery.

This work was done by Gregory H. Bearman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 11*** *on the TSP Request Card. NPO-19364*

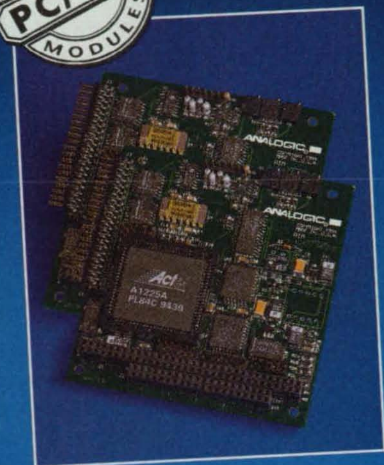
Sinterless Formation of Contacts on Indium Phosphide

Heat is unnecessary to achieve low contact resistance.

Lewis Research Center, Cleveland, Ohio

An improved technique makes it possible to form low-resistivity ($\approx 10^{-6}\,\Omega\cdot cm^2$) electrical contacts on indium phosphide semiconductor devices without damaging the devices. Previously, metal contacts were deposited on n-doped InP and sintered to reduce the contact resistivity. The sintering process caused intermixing of the metal and semiconductor, destroying all but the deepest junctions under the contacts. In the improved technique, a layer of AgP_2 40 Å thick is deposited on the InP before depositing a metal contact. The AgP_2 interlayer sharply reduces the contact resistance, without need for sintering.

This work was done by Victor G. Weizer and Navid S. Fatemi of Sverdrup Technology Corp. for **Lewis Research Center**. *For further information,* ***write in 4*** *on the TSP Request Card. LEW-15814*



Multilayer Active Control for Structural Damping and Optical-Path Regulation

Two control concepts are combined.

NASA's Jet Propulsion Laboratory, Pasadena, California

Two active-control concepts have been incorporated into a system for suppression of vibrations in a truss structure and regulation of the length of an optical path on the structure to the nanometer level. In the original intended application, the structure would be a lightweight truss structure supporting a stellar interferometer in zero gravitation. However, the control concepts should also be applicable wherever there is a need to maintain high precision and make a lightweight structure behave as though it had the stiffness of a much heavier structure.

One of the active-control concepts involves direct control of the length of the optical path, one end of which lies within a retroreflective optical assembly. In an experimental version, the optical assembly is mounted on a trolley, attached via flexures and a low-frequency large-amplitude voice coil actuator to the free upper end of a tower-like cantilevered flexible structure. A lightweight mirror within the assembly is mounted on a high-frequency, small-amplitude piezoelectric actuator. The two actuators respond to measurements from optical-path-length sensors: the outputs of the sensors are processed into actuator commands by a feedback control subsystem (see Figure 1). This concept has been described in more detail in a number of previous articles, including "Stabilizing Optical-Path Length on a Vibrating Structure" (NPO-19040), *NASA Tech Briefs*, Vol. 19, No. 8 (August, 1995), page 48; "Controllable Optical Delay Line for Stellar Interferometry" (NPO-18686), *Laser Tech Briefs*, Vol. 1, No. 1 (September, 1993), page 44; and "Test Bed for Control of Optical-Path Lengths" (NPO-18487), *Laser Tech Briefs*, Vol. 2, No. 1 (Winter, 1994), page 61.

The other active-control concept, called "dial-a-strut", has also been discussed in previous articles, though not under its present name. In dial-a-strut control, one uses active structural members (struts that contain both sensors and actuators) in conjunction with active feedback control subsystems to achieve a form of active damping in which each active member acts like a passive damper in a frequency range of interest. Ideally, one would optimize damping by making the effective mechanical impedance of an actively controlled member equal to the complex conjugate of the mechanical impedance of the rest of the structure. In practice, this is not feasible, and instead one adjusts dials on the front panel of the control electronics (hence the name, "dial-a-strut") to adjust the effective stiffness and damping parameters of the controlled strut to match the magnitude of the impedance of the strut to a smoothed (in terms of frequency dependence) approximation of the magnitude of impedance of the rest of the structure (see Figure 2). The results of the experiments indicate that the combination of optical-path-length control and dial-a-strut control is effective for stellar interferometer applications.

This work was done by Zahidul H. Rahman, John T. Spanos, and James L. Fanson of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 57*** *on the TSP Request Card. NPO-19041*

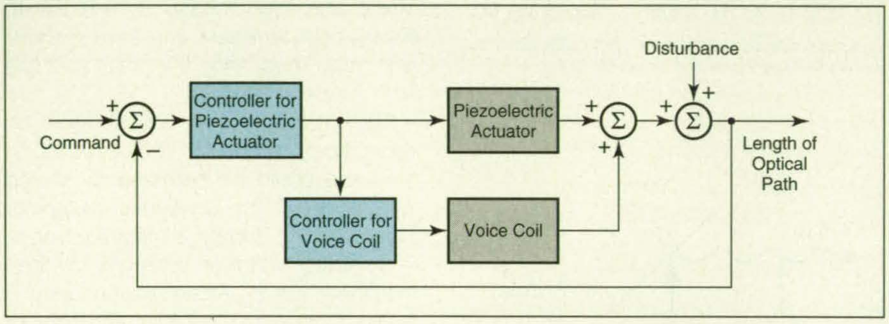


Figure 1. The **Optical-Path-Length-Control Subsystem** contains two feedback control loops to obtain active damping in a wide amplitude-and-frequency range.

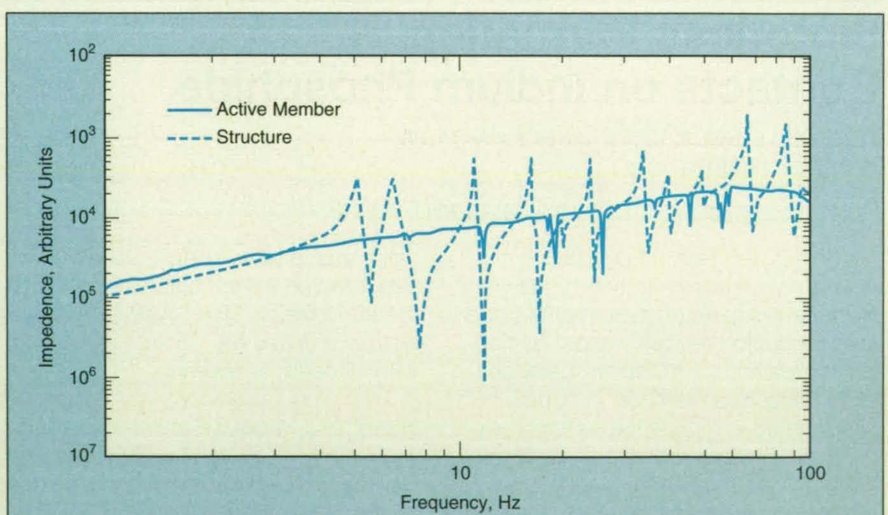


Figure 2. The **Impedance-vs.-Frequency** response of an experimental actively controlled structural member was adjusted to a smooth approximation of the impedance of the rest of the structure.

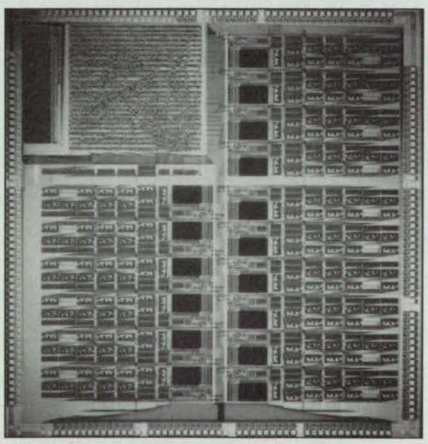
Systolic Processor Array for Recognition of Spectra

Spectral signatures of materials would be detected and identified quickly.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed systolic array of digital data processors would quickly detect and identify spectral signatures of materials of interest that appear in images produced by advanced imaging spectrometers of high spectral resolution. Called the Spectral Analysis Systolic Processor Array (SPA^2), this array would be relatively inexpensive and would satisfy the need to analyze the large, complex volume of multispectral data generated by imaging spectrometers to extract the desired information: the computational performance needed to do this in real time exceeds that of current supercomputers.

The SPA^2 would be able to locate highly similar segments or contiguous subsegments in two different spectra at a time. Exploiting this capability, the SPA^2 could compare sampled spectra from instruments with a data base of spectral signatures of known materials. The SPA^2 would compute and report scores that would express the degrees of similarity between the sampled and data-base spectra. Higher scores would be deemed to indicate that the material(s) of interest had been detected at the sampling locations in the spectral images.



The **Biological Information Signal Processor** would be the building block of the SPA^2.

The building block of the SPA^2 would be a 400,000-transistor complementary metal oxide/semiconductor very-large-scale integrated circuit chip called the "Biological Information Signal Processor" (BISP). This chip (see figure) contains 16 processing elements that operate at a clock frequency of 12.5 MHz. It can compare spectral images as long as 4,194,304 elements. The SPA^2 composed of BISPs could operate orders of magnitude faster than does a CRAY-2 computer, yet it would fit in a package smaller than 20 cm^3.

This work was done by Edward T. Chow and John C. Peterson of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 22*** *on the TSP Request Card. NPO-18808*

Computer-Aided Air-Traffic Control in the Terminal Area

Ames Research Center, Moffett Field, California

A developmental computer-aided system for the automated management and control of arrival traffic at a large airport would include three integrated subsystems. One subsystem, called the Traffic Management Advisor, establishes optimized landing sequences and landing times for aircraft arriving in designated airspace several hundred miles from the airport. Another subsystem, called the Descent Advisor, generates advisory data for fuel-efficient and conflict-free de-scents of aircraft assigned to available terminal gates. The third subsystem, called the Final Approach Spacing Tool, provides heading and speed clearances that produce an accurately spaced flow of aircraft on their final approaches. A data base that includes current wind measurements and mathematical models of performances of types of aircraft contributes to effective operation of the system.

This work was done by Heinz Erzberger of **Ames Research Center**. *For further information,* ***write in 58*** *on the TSP Request Card. ARC-13332*

Process-Information Display Panel for Welder's Visor

Information would be presented adjacent to the welder's usual field of view.

Marshall Space Flight Center, Alabama

A head-up display (HUD) unit would be mounted in a welder's visor or helmet (see Figure 1) to provide process information in real time, according to a proposal. Until now, success in manual welding has depended on the welder's training and intuition in judging the progress of a weld by interpreting sights and sounds. The proposed display would enable the welder to gain greater awareness of the effects of welding while controlling the welding process in the usual way(s) by use of a foot pedal, voice command, and/or manipulation of the welding torch. Data

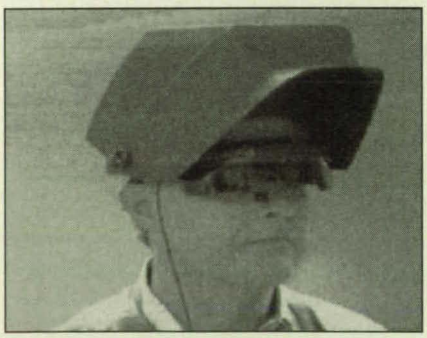


Figure 1. A **Compact Head-Mounted Display Unit** like this commercial one developed for a different purpose would be mounted in a welder's visor or helmet.

obtained during the welding process could be used to compare welding performance with a guideline or model performance established through laboratory tests or through a data base compiled from experience, making it possible to avoid the need for every new welder on the job to solve the same problems that were previously solved by other welders.

One candidate design concept calls for a fully packaged HUD that would present computer-generated graphics adjacent to the normal viewing window of the welder's visor or helmet (see Figure 2). The virtual-reality industry has created a new generation of such devices, with color and with resolutions of as much as 640 × 480 pixels and with higher-resolution units expected to come to market. Some modifications may be necessary to mount the display unit in the visor or helmet.

The HUD could be used, for example, to inform the welder of binary parameters like the states of solenoid-actuated switches and valves. Such continuously varying parameters as the rate of travel of the torch along the workpiece could be depicted by use of arrows, the lengths of which would be proportional to the deviations of the parameters from desired values or ranges of values. Colors could also play a key role; for example, the color of an arrow could be made to change from yellow to red as the error increased to an intolerable level. Such symbolic representation of the data would favor quick, intuitive interpretation.

In many cases, manual arc welding (as contrasted with automated arc welding) still offers the best balance of setup time, production volume, capital investment, and quality. Display devices of the proposed type could be especially beneficial in supporting and enhancing the continued practice of manual arc welding in such cases; even NASA and its contractors continue to use manual arc welding for fabrication and repair of much flight hardware and ground support equipment. The proposed display devices could also be of

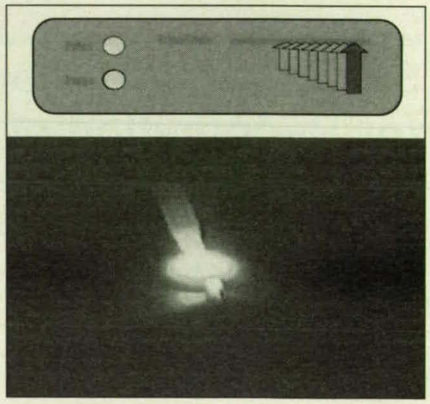


Figure 2. A **Graphical Display** would be presented to the welder, adjacent to the normal field of view through the visor.

value in industries that invest millions of technician-hours each year in manual arc welding for a variety of products.

This work was done by Carolyn Russell of **Marshall Space Flight Center** *and Ken Gangl of Advanced Welding Concepts, Inc. No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26322.

Five-Channel Polychromator Head

This device is part of a Raman-scattering temperature-measuring system.

Marshall Space Flight Center, Alabama

Figure 1 illustrates the five-channel polychromator head of a laser Raman polychromator that is being developed for use in measuring the rotational temperatures of H_2 molecules in subscale combustors. Each channel consists of a 1-mm fiber-optic cable that is individually translatable along the dispersion axis of a spectrometer to provide both flexibility and fine-tuning capability.

The basic idea is to measure the temperature in terms of the temperature dependence of Raman scattering of a laser beam from hydrogen molecules in the Q branch of the vibrational ground state. The Raman-scattered light can be resolved into a small number of spectral lines, the relative intensities of which indicate the population distribution of the hydrogen molecules in various rotational states. These spectral lines are denoted by their rotational quantum numbers, J, and the ratio between the intensities of any two of these spectral lines is related in a known way to the temperature at the point of measurement.

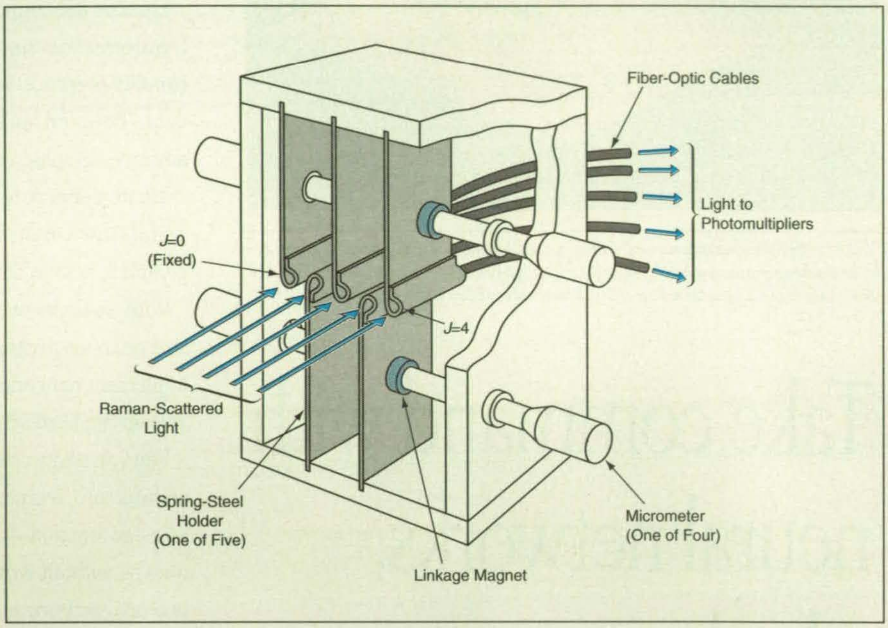


Figure 1. The **Five-Channel Polychromator Head** samples the Raman-scattering spectrum simultaneously at five wavelengths.

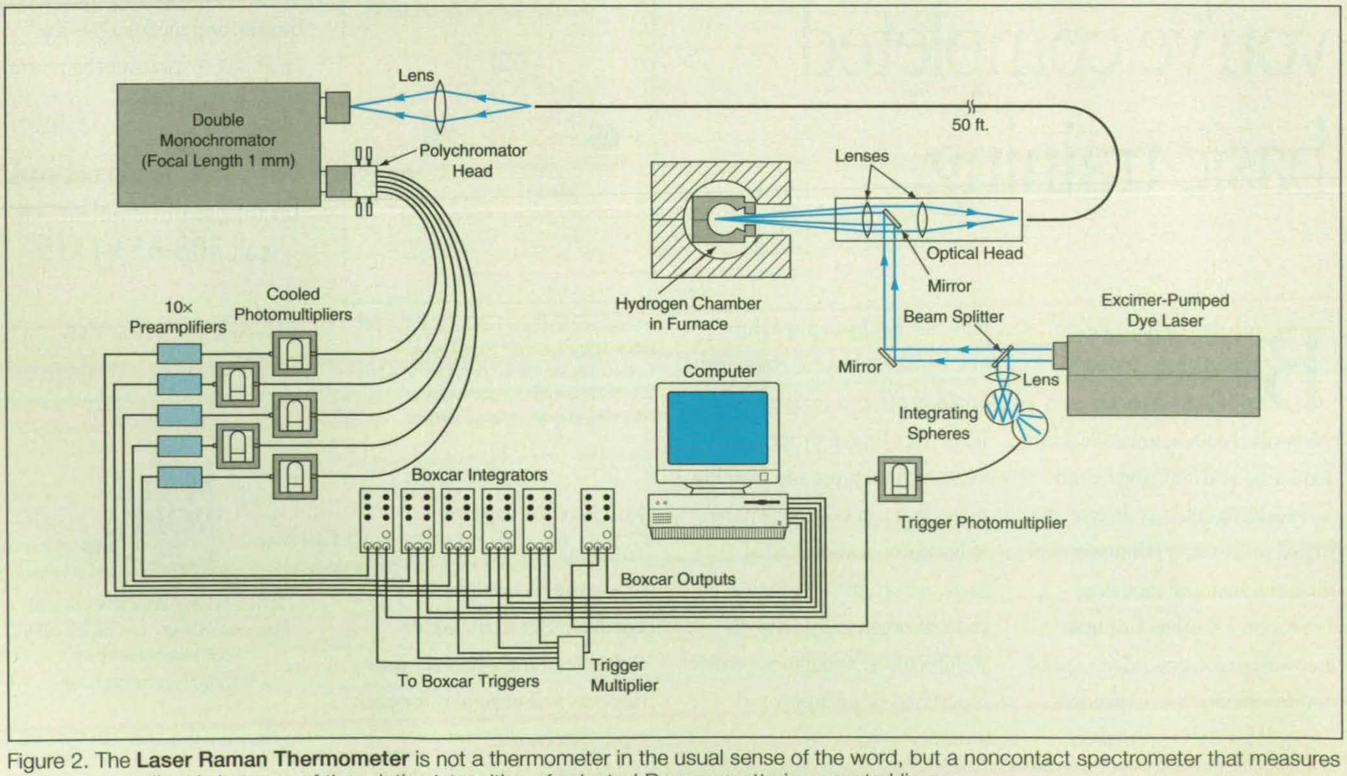
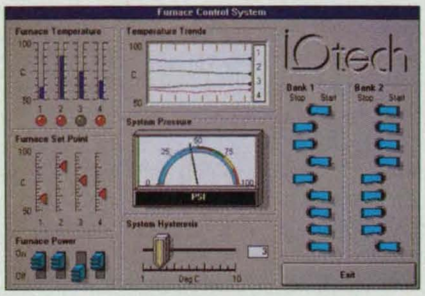


Figure 2. The **Laser Raman Thermometer** is not a thermometer in the usual sense of the word, but a noncontact spectrometer that measures temperature indirectly in terms of the relative intensities of selected Raman-scattering spectral lines.

Temperature & Voltage Measurement

The 19" rack-mountable MultiScan/1200™ temperature and voltage measurement instrument offers both channel-to-channel isolation and high accuracy. It can scan thermocouples and volts at up to 147 channels/s and digitize waveforms at up to 20 kHz. It can accept 24 differential voltage and temperature inputs, and can be easily expanded up to 744 channels. $2490. IOtech, Inc. (216) 439-4091.

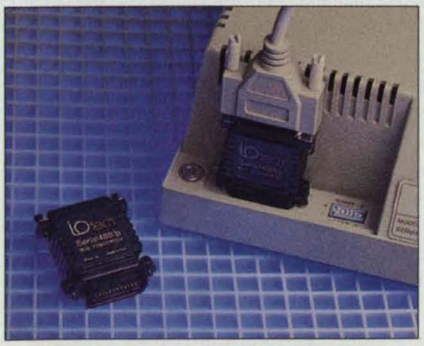
For More Information Write In No. 662



Visual Basic™ Software Tools

VisuaLab 4.0™ software provides Visual Basic™ users with over 100 point-and-click tools for adding graphical user interfaces (GUIs), charts, and statistics and analysis functions to their data acquisition and IEEE 488 control applications. $395. IOtech, Inc. (216) 439-4091.

For More Information Write In No. 663



Compact Serial/IEEE 488 Converter

The 2" x 2.3" Serial488/p™ serial-to-IEEE 488 converter enables users to directly link a PC or workstation to an IEEE 488 plotter or printer, such as a Hewlett-Packard ThinkJet™ printer. The miniature converter draws its power from the computer's serial port and can be connected to it directly or via cable. The Serial488/p incorporates a 120-character buffer, and it accepts RS-232C data at 9600 bps. $295. IOtech, Inc. (216) 439-4091.

For More Information Write In No. 664

The five-channel polychromator is used in conjunction with five photomultipliers (one photomultiplier for each channel) for simultaneous measurement of the J = 0 through J = 4 transitions of the v = 0 → v = 1 Q branch. The photomultipliers offer high sensitivity and dynamic range, and the multiple channels eliminate the need for time-consuming scanning.

Figure 2 illustrates the laboratory configuration of the Raman thermometer in which the five-channel polychromator head is installed. The head is mounted on the exit plane of a double monochromator (spectrometer) with plane holographic gratings of 2,400 grooves/mm. The reciprocal linear dispersion at the middle of the spectrum (wavelength of 538 nm) is 0.14 nm/mm. The output signal of each individual fiber-optic cable is sent to a separate photomultiplier, the output of which is sent to a signal-conditioning amplifier. The outputs of the amplifiers are gated and boxcar-averaged. A computer digitizes, stores, and analyzes the boxcar-averaged data via real-time algorithms.

This work was done by Richard Eskridge, Chris Dobson, Mike Lee, and Tony Robertson of **Marshall Space Flight Center.** *For further information,* ***write in 46*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-28846.

Improved Bakeout Chambers Within Vacuum Chambers

Heated enclaves reduce contamination further.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure illustrates schematically one of several vacuum-bakeout chambers that have been redesigned to reduce contamination. When operated according to a revised bakeout procedure, they yield measurements of contamination on vacuum-bake test articles more accurate than were available previously, and the potential for post-bake recontamination of the vacuum-baked articles is reduced.

These chambers are improved versions of the one described in "Bakeout Chamber Within Vacuum Chamber" (NPO-18959), *NASA Tech Briefs*, Vol. 19, No. 5 (May, 1995), page 52. As before, each of the present vacuum-bakeout chambers includes an inner heated chamber surrounded by an insulating blanket that is, in turn, surrounded by a cold shroud, all mounted within a conventional vacuum chamber. The heated inner chamber, previously called a "bakeout chamber," is now called an "enclave." The cold shroud is cooled by flowing liquid nitrogen: the cold shroud is used to reduce background pressure in the vacuum chamber and thereby reduce the deposition of background contamination on contamination detectors located near the bakeout chamber.

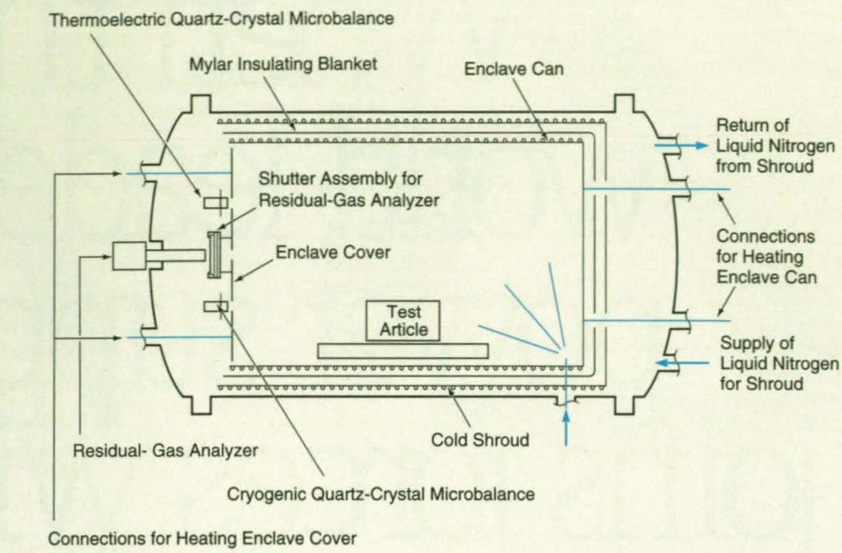
The improvements in design and bakeout procedure were made to satisfy the following three criteria: (1) A test article must not become contaminated by outgassed volatile materials at any time during bakeout, contamination-level testing, or post-test warmup of the cold shroud; (2) The background rate of outgassing by the chamber hardware must be negligibly small in comparison with that of the test article; and (3) the method used to measure contamination must positively verify that the required degree of cleanliness has been achieved.

The enclave consists mostly of a can and cover made of stainless steel and electropolished to remove contamination embedded in their surfaces. Contamination detectors of several different types (residual-gas analyzer, thermoelectric quartz-crystal microbalance, and cryogenic quartz-crystal microbalance) are mounted facing orifices in the cover, so that their directional sensitivity patterns cause them to measure predominantly the outgassed contaminants that stream from the enclave through the orifices. The measurement of contamination involves a multistep procedure in which the various detec-

tors are operated at various temperatures and pressures.

By enclosing the test article in the enclave and keeping the walls of the enclave hotter than the test article during bakeout, one prevents condensation of contaminants on the inner walls of the enclave. In preparation for measurement of contamination of the test article, the background rate of outgassing by the chamber hardware is minimized by baking the enclave at a temperature greater than the maximum expected operating temperature of the test article. During bakeout, contaminants leave the enclave through the orifices and are removed from the vacuum chamber — some by the vacuum-chamber pump, others by condensing onto the cold shroud.

After bakeout is complete and before a post-bakeout test of cleanliness of the test article, the enclave is cooled slowly enough to prevent the condensation of volatile contaminants that are still being emitted from the test article (contaminants are still being emitted because the temperature of the test article lags behind the temperature of the enclave; that is, the test article is still hot at this phase of operation). After the post-bakeout test, the shroud is warmed slowly enough to limit the flux of desorption from the shroud to an acceptably low level, while the enclave is purged with high-purity gaseous nitrogen to minimize backstreaming of contaminants into the enclave.



This **Improved Bakeout Chamber** incorporates hardware features that, in conjunction with an improved bakeout procedure, reduce spurious contamination and increase the accuracy of contamination measurements.

This work was done by Kenneth R. Johnson, Daniel M. Taylor, Robert W. Lane, Maximo G. Cortez, and Mark R. Anderson of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 96*** *on the TSP Request Card. NPO-19015*

Techniques for Topographical Mapping via Interferometric SAR

Data-processing techniques combined with advanced navigational capabilities yield terrain-height maps.

NASA's Jet Propulsion Laboratory, Pasadena, California

Two techniques for processing data acquired by an airborne interferometric synthetic-aperture-radar (SAR) system yield terrain-height maps. The techniques are predicated on the availability of an accurate navigational system that yields data on the motion and orientation of the airplane that carries the SAR system and, thus, also effectively gives the orientation of the baseline between the two radar antennas of the system.

The figure presents a simplified view of the broadside-looking interferometric-SAR geometry. For an SAR system operating at a wavelength $\lambda = c/f$ (where c = the speed of light and f = the radar carrier frequency), the phase shift, ϕ, between the radar returns received at the two antennas is given by

$$\frac{\phi\lambda}{2\pi} = |\mathbf{r}_{21}|\cos(\theta - \theta_{21})$$

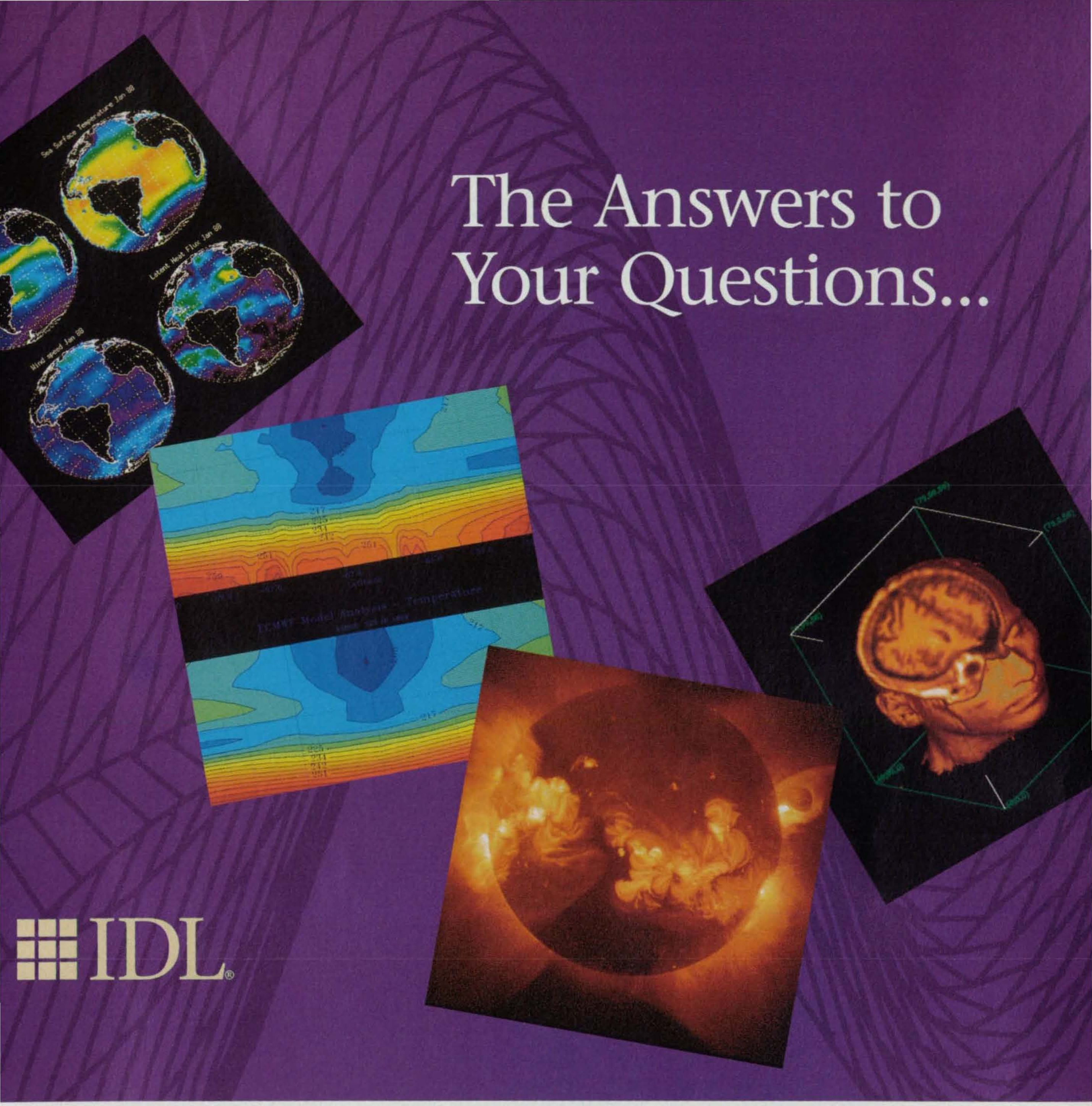
where $\mathbf{r}_{21}$ is the baseline vector between the two antennas and θ_{21} is the angle of this baseline above the nadir direction. This angle can be computed from the navigational data. The other quantities indicated in the figure are given by

$$\theta = \theta_{21} + \arccos\left(\frac{\phi\lambda}{2\pi|\mathbf{r}_{21}|}\right)$$

$$h = H - r\cos\theta, \text{ and } y = r\sin\theta.$$

Thus, in principle, the three-dimensional coordinates of a target point on the terrain can be determined from (1) the position and orientation of the airplane as given by the navigational system and (2) the slant range r and phase shift ϕ as measured by the SAR system.

One of the two techniques resolves the $2\pi N$ ambiguity (where N is an integer) in the measured value of ϕ, enabling an absolute determination of the terrain height h. In an older technique, this ambiguity was resolved by use of a reference terrain point of known elevation. In the present technique, no a priori elevational information is needed: Instead, this technique involves the construction of a differential SAR interfero-



Immediately gain insight from your data with IDL, the pioneering software for interactive analysis and application development. If you analyze data from tests, experiments, simulations, or images – or write applications for others to use – IDL will give you clear results faster.

Dramatically improve your productivity using IDL for visual data analysis, rapid prototyping, or application development. Nothing else provides the speed, flexibility, and breadth of built-in functions for access, manipulation, and display of scientific and engineering data.

See results "on the fly" with integrated graphics, image processing, mathematics, and statistics. Quickly turn your ideas into powerful applications using IDL's high-level, array-oriented programming language and cross-platform GUI tools.

A few lines of IDL code can do the job of hundreds of lines of C or Fortran, without sacrificing flexibility or performance. Plus, you can call functions in other languages or link IDL to your C or Fortran applications.

IDL programs are portable. You can deliver complete solutions on UNIX®, VMS™, Windows, Windows NT™, Macintosh® and Power Macintosh, while writing programs only once.

So why waste time starting from scratch? Exploit IDL and find the answers – in less time, with less programming, and less hassle.

SEE THE ANSWERS FOR YOURSELF

For a free evaluation copy, call

303-786-9900

Email: info@rsinc.com/Fax: 303-786-9909

Software ≡ Vision™

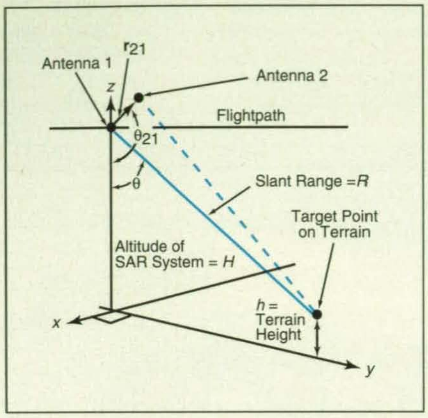
Research Systems, Inc.
2995 Wilderness Place
Boulder CO 80301

Research Systems, Inc. is represented by the following distributors: **GERMANY** CREASO, GmbH 49 8105 25055 • **FRANCE** Fast Parallel Solutions 33 1 46 87 25 22 • **UK** Floating Point Systems UK Ltd. 44 734 776333 • **ITALY** Alliant Computer Systems SRL 39 39 6091766 • **JAPAN** Adam Net Ltd. 81 35802 2251 • **BRAZIL** SulSoft 55 51 488 22 57 • **KOREA** InterSys 82 42 869 4746

For More Information Write In No. 555

gram within which the maximum variation of phase is less than 2π.

First, SAR data are acquired at two slightly different frequencies f_u and f_l, which could be, for example, sidebands of the carrier frequency f. Then the difference $\Delta\phi$ between the phase shifts at the two frequencies is computed. In principle, $\Delta\phi = (f_u - f_l)\phi/f$; thus, by choosing f_u and f_l sufficiently close, one can restrict the range of $\Delta\phi$ to less than 2π. Also in principle, one can then compute an unambiguous value of ϕ from $\phi = f\Delta\phi/(f_u - f_l)$. In practice, this computation amplifies the phase noise in the differential interferogram, and it is necessary to average the noisy computed phase over an image patch containing a large number of pixels to determine N.



The **Three-Dimensional Coordinates** of a target point can be computed if the position along the flightpath, the angle θ of the line of sight, and the slant range are known.

The other technique is an algorithm for efficient computation of the three-dimensional coordinates of a target point. The algorithm computes the unit vector along the slant range from ϕ, $\mathbf{r}_{21}$, and the velocity of the airplane (which affects the Doppler centroid frequency). It computes the position of the target point, relative to the airplane, as the product of the slant range and the unit vector along the slant range. Then it adds this relative-position vector to the position vector of the airplane to obtain the position vector of the target point.

This work was done by Soren N. Madsen, Howard A. Zebker, and Jan M. Martin of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 193*** *on the TSP Request Card. NPO-18840*

Verifying Dissolution of Wax From Hardware Surfaces

Wax removed by cleaning solvent is revealed by cooling the solution with liquid nitrogen.

Marshall Space Flight Center, Alabama

An improved solvent cleaning procedure and associated cleanliness test have been devised for removing wax that previously coated a piece of hardware and for verifying that the wax has been removed. Such a procedure and test are needed in the case of hardware that must be protected by wax during machining or plating but is required to be free of wax during subsequent use. In a previous solvent cleaning procedure and cleanliness test, carbon tetrachloride (which is highly toxic) was used as the solvent, and infrared spectroscopy was used to detect wax in the solvent flushings. A typical infrared analysis took as long as 2 1/2 hours.

The improved cleaning procedure and test take less than 5 minutes. Unlike the previous infrared-analysis cleanliness test, the improved test does not require special skill or equipment and can be performed at the cleaning site. In addition, the improved procedure and test enable recovery of all the cleaning solvent.

In the improved cleaning procedure, one uses 1,1,1-trichloroethane or perchloroethylene as the solvent. In the improved cleanliness test, liquid nitrogen, in a proportion of up to 40 volume percent, is mixed into the solvent flushings to cool them. The same proportion of liquid nitrogen is mixed into an equal amount of solvent known to be pure. If the solvent flushings contain a significant quantity of wax, a separate waxy phase collects on top of the flushing solution and can be identified by visual comparison with the clean solution.

This work was done by Benjamina G. Montoya of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 51*** *on the TSP Request Card. MFS-29978*

Simple Magnetic Device Indicates Thickness of Alloy 903

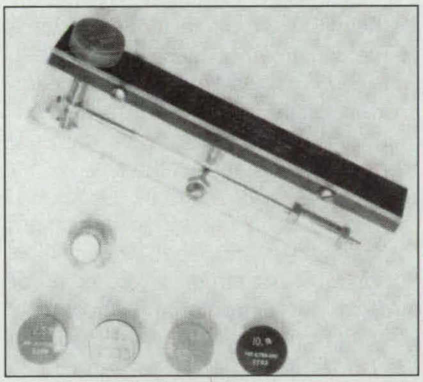
Relative strength of attraction shows whether an alloy overlay is thinner than allowable.

Marshall Space Flight Center, Alabama

The figure illustrates a simple, hand-held, magnetic device that can be used to determine whether an overlay of alloy 903 on a body of alloy 718 is thinner than allowable in a specific application. The device is called a "ferrite indicator" and was originally designed to be used in determining the ferrite content of a specimen of steel. It is placed in contact with the specimen and functions by indicating whether a magnet that it contains is attracted more strongly to the specimen or to a calibrated reference sample.

An experiment showed that the magnetic characteristics of alloy 903 make it suitable for inspection of overlays of this material by the ferrite-indicator technique. In the application that motivated the experiment, there was a need to ensure that the overlay of alloy 903 was at least 0.020 in. (about 0.5 mm) thick. In the experiment, one of the available reference samples gave an indication of 0.025 in. (about 0.6 mm). [The extra 0.005 in. (about 0.1 mm) can be used to advantage as a margin of safety.]

This work was done by Pin Jeng Long, Sergio Rodriguez, and Mark L. Bright of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 100*** *on the TSP Request Card. MFS-29980*



The **Ferrite Indicator** is shown here with several reference samples.

Slide Rule for Calculating Curing Schedules

Marshall Space Fight Center, Alabama

A special-purpose slide rule has been devised for calculating schedules for storing and curing adhesives, sealants, and other materials that are characterized by known curing times and shelf lives. The use of the slide rule can prevent mistakes that are commonly made in determining storage and curing schedules. The slide rule is calibrated in days and hours. In using the slide rule, one simply selects the curing time and the starting calendar day and time; the slide rule indicates the number of days of curing and the hour when cure will be completed on the final day. It is, however, necessary to account separately for the number of days when the cure extends into the following month.

This work was done by Don Heater of Thiokol Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 93*** *on the TSP Request Card. MFS-28938*

Trimethoxymethane: A Fuel for Direct-Oxidation Fuel Cells

Trimethoxymethane can be oxidized to CO_2 and H_2O at high rates, without poisoning electrodes.

NASA's Jet Propulsion Laboratory, Pasadena, California

Trimethoxymethane (TMM) has been identified as a high-energy fuel for direct-oxidation fuel cells. TMM can be synthesized from natural gas (methane) and can be handled easily because it is a non-toxic, low-vapor-pressure liquid. Data obtained from both half-cell and full-cell tests indicate that TMM can be oxidized at very high rates. Thus, TMM is considered to be an excellent candidate for use in direct-oxidation fuel cells in vehicles and portable power supplies.

The electrochemical oxidation of TMM, represented by

$$(CH_3O)_3CH + 5H_2O \rightarrow 4CO_2 + 20H^+ + 20e^-,$$

has been studied in experiments in half cells in which the electrolyte was 0.5 M sulfuric acid and the electrocatalysts were Pt/Sn and Pt/Ru electrodes. It was found that TMM can be oxidized at potentials considerably more negative than those of methanol. As shown by the data plotted in Figure 1, increasing the concentration of TMM increases the kinetics of its oxidation. The kinetics are also increased by increasing the temperature: at temperatures as high as 60 °C, the rate of oxidation is twice that at 25 °C.

Experiments on the direct oxidation of TMM were carried out in a liquid-feed-type fuel cell developed previously for direct oxidation of methanol. In this cell, Nafion 117, a commercial proton-conducting solid-polymer membrane, was used as the electrolyte. The membrane electrode assembly included a specially constructed fuel-oxidation electrode made of an unsupported Pt/Ru catalyst layer (4 mg/cm^2) and a gas-diffusion-type unsupported platinum electrode (4 mg/cm^2) for the reduction of oxygen. A fuel solution of 2 M TMM was circulated past the anode of the cell, while oxygen at a pressure of 20 psi (≈140 kPa) was applied to the cathode. The CO_2 produced by the oxidation of TMM was easily separated from the fuel solution in a tall glass column.

Analysis revealed no oxidation products other than methanol, which may be an intermediate product in the process of oxidation of TMM to carbon dioxide and water. Inasmuch as the particular fuel cell was designed to handle methanol in the first place, the presence of methanol is no cause for concern. Figure 2 shows current-vs.-voltage characteristics of the cell in an experiment using TMM and in another experiment using methanol as the fuel.

This work was done by George A. Olah, Surya G. Prakash, Sekharipuram R. Narayanan, Eugene Vamos, and Subbarao Surampudi of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 63*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

William T. Callaghan, Manager
Technology Commercialization
JPL-301-350
4800 Oak Grove Drive
Pasadena, CA 91109

Refer to NPO-19228, volume and number of this NASA Tech Briefs *issue, and the page number.*

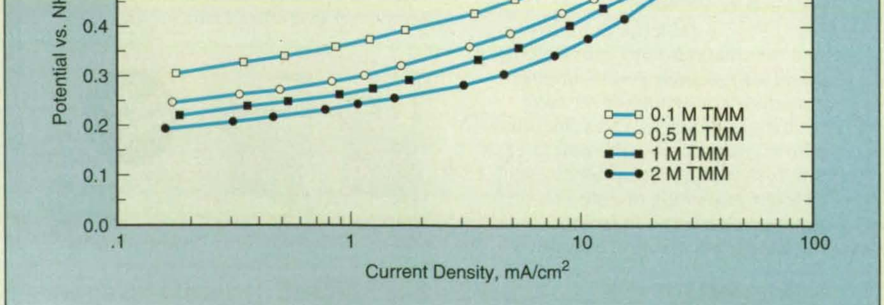


Figure 1. These **Galvanostatic Polarization Curves** show the electro-oxidation characteristics of several concentrations of TMM at Pt/Sn electrodes of the gas-diffusion type, at room temperature, in a solution with 0.5 M H_2SO_4 and 0.01 M perfluorooctanesulfonic acid (C_8 acid) at 25 °C.

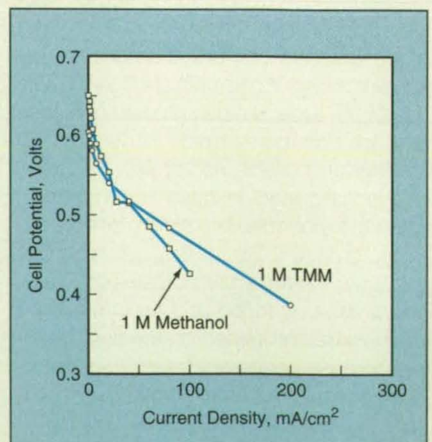


Figure 2. The **Current-vs.-Voltage Characteristics** of a liquid-feed direct-oxidation fuel were measured with TMM and with methanol as the fuel at 60 °C.

GE PLASTICS

GE Plastics' New Material Selection Database, GE Select™, Is The Most Comprehensive Ever

GE Plastics has unveiled a new disk-based material selection database designed to make the specification of its engineering thermoplastics easier than ever before. This comprehensive database, named GE Select, covers the diverse family of GE polymers and provides complete properties and engineering data on over 500 commercially available resin grades.

The data is presented in an easy-to-use format designed to help engineers maximize material potential, optimize material usage, and eliminate costly over-design. GE Select was developed by GE Plastics' Advanced Design Engineering group and drew heavily on results from a comprehensive survey of design engineers from across the U.S. Many of the engineers surveyed said they would prefer a disk-based system as opposed to accessing an engineering database via an on-line service. GE Select is the answer to this and many other customer needs.

User-Friendly Format

Once a user has determined some or all of the performance criteria required for an application, he or she accesses the GE Select program. The database opens automatically with material and grade names displayed in a Grade Table Window. By using a Material Selection dialog box, users can conduct a search of product grade property profiles to match specific application requirements.

GE Select searches the database and displays property information and engineering data for those resin grades that meet the criteria established by the user.

Special functions on the menu bar permit the plotting of engineering data, such as Tensile Stress vs. Strain, for product/grade comparisons. GE Select also allows users to overlay combinations of materials and test parameters—a key feature for design engineers. Engineering data available on GE Select include: Tensile Creep Data, Tensile Fatigue Data, Dynamic Mechanical Analysis Data, and Rheology Data.

With GE Select, users can customize query windows, browse through material data sheets and display engineering data from the GE Engineering Design Database (EDD).

Easy Access

The two-disk program is available in both Microsoft® Windows and Macintosh® formats. It also can be downloaded directly from the Internet by accessing GE Plastics' www.ge.com on-line address.

For more information on GE Select, call 800-845-0600.

For More Information Write In No. 533

Dimethoxymethane: A Fuel for Direct-Oxidation Fuel Cells

This fuel can be electro-oxidized at sustained high rates without poisoning electrodes.

NASA's Jet Propulsion Laboratory, Pasadena, California

Dimethoxymethane (also called methylal), is a nontoxic liquid that has been identified as one of several high-energy fuels for direct-oxidation fuel cells. DMM has been found to undergo facile electro-oxidation to carbon dioxide and water, with methanol as a possible intermediate product. The electro-oxidation is catalyzed at Pt/Sn and Pt/Ru electrodes. The high rates of oxidation sustained by DMM make it possible to operate liquid-feed cells at significant power densities at temperatures close to ambient. The performance of DMM is superior to that of methanol at the same temperature. DMM can be synthesized from natural gas (methane) and is thus a viable alternative to methanol in direct-oxidation fuel cells.

The electro-oxidation of DMM involves a series of dissociative adsorption steps followed by a surface reaction to form carbon dioxide and water. The electro-oxidation reaction is represented by

$$(CH_3O)_2CH_2 + 4\,H_2O \rightarrow 3\,CO_2 + 16\,H^+ + 16\,e^-$$

Experiments on the electro-oxidation of DMM were carried out in half cells in which the electrolyte was 0.5 M sulfuric acid and the electrocatalysts were gas-diffusion-type Pt/Sn and Pt/Ru electrodes. It was found that DMM can be oxidized at potentials considerably more negative than those of methanol.

Although increasing the temperature was found to increase the rate of oxidation significantly, the low boiling temperature of DMM (41 °C) made it impractical to use temperatures greater than 37 °C in the half-cell experiments. As shown in Figure 1, increasing the concentration of DMM increases the rate of its oxidation.

Experiments on the direct oxidation of DMM were carried out in a liquid-feed-type fuel cell developed previously for direct oxidation of methanol. In this cell, the electrolyte was a membrane of Nafion 117, which is a commercial proton-conducting solid polymer. The membrane electrode assembly included a specially constructed fuel-oxidizing electrode made of an unsupported Pt/Ru catalyst layer (4 mg/cm^2) and a gas-diffusion-type unsupported platinum electrode (4 mg/cm^2) for the reduction of oxygen. A fuel solution of 1 M DMM was circulated past the fuel-oxidizing (anode) side of the cell, while oxygen was supplied to the cathode at a pressure of 20 psi (≈140 kPa). The carbon dioxide produced by the oxidation of DMM was easily separated from the fuel solution in a tall glass column.

Analysis revealed no oxidation products other than methanol, which may be an intermediate product of the process of oxidation of DMM to CO_2 and H_2O. The presence of methanol is not a cause for concern because the fuel cell was designed for use with methanol and the methanol is ultimately oxidized to carbon dioxide and water.

Figure 2 shows the current-vs.-voltage characteristic of the cell at 37 °C. The cell potential was 0.20 V at a current density of 50 mA/cm^2; this performance was comparable to that obtained using methanol as the fuel. Better performance is expected at higher temperature and by use of Pt/Sn catalyst. Alternatively, the low boiling temperature of DMM also makes it a candidate for a gas-feed operation.

This work was done by George A. Olah, Surya G. Prakash, Sekharipuram R. Narayanan, Eugene Vamos, and Gerald Halpert of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 81*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

William T. Callaghan, Manager
Technology Commercialization
JPL-301-350
4800 Oak Grove Drive
Pasadena, CA 91109

Refer to NPO-19229, volume and number of this NASA Tech Briefs *issue, and the page number.*

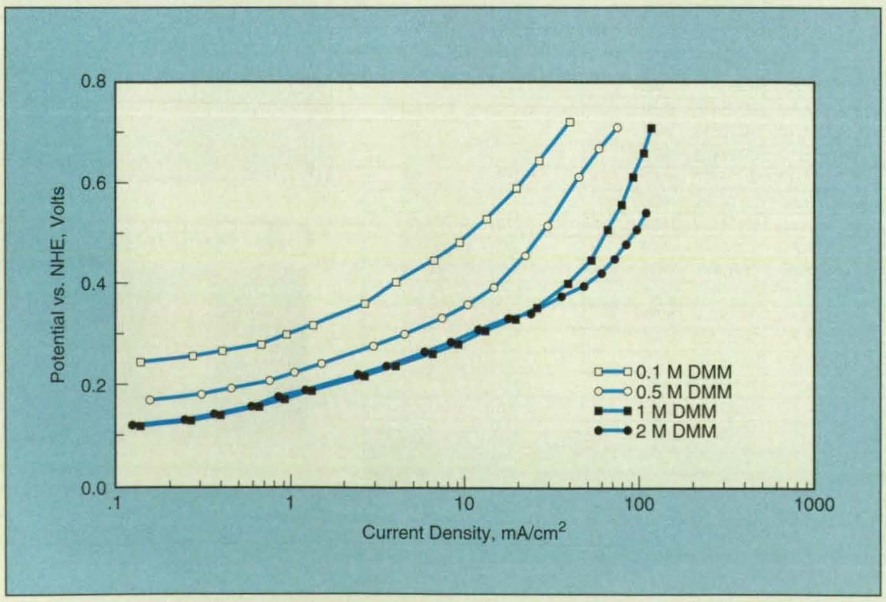


Figure 1. These **Galvanostatic Polarization Curves** show the electro-oxidation characteristics of several concentrations of DMM at Pt/Sn electrodes of the gas-diffusion type, at room temperature, in a solution with 0.5 M H_2SO_4 and 0.01 M perfluorooctanesulfonic acid (C_8 acid).

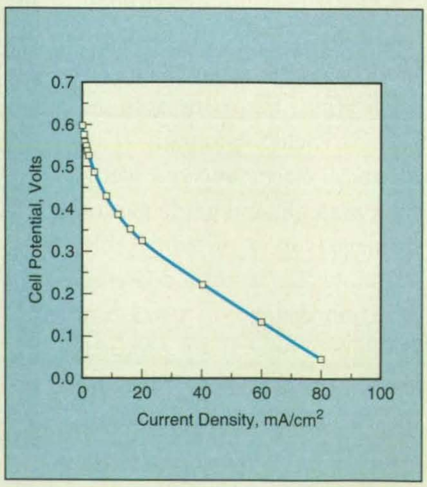


Figure 2. The **Current-vs.-Voltage Characteristics** of a liquid-feed direct-oxidation fuel were measured with DMM at 37 °C.

Trioxane: A Fuel for Direct-Oxidation Fuel Cells

Trioxane can be used as a substitute for formaldehyde.

NASA's Jet Propulsion Laboratory, Pasadena, California

Trioxane has been identified as a high-energy, nontoxic, solid substitute for formaldehyde as a water-soluble fuel for use in direct-oxidation fuel cells. Trioxane has been found to undergo facile electrochemical oxidation to water and carbon dioxide at platinum and platinum-alloy electrodes in liquid-feed-type fuel cells that contain acid electrolytes or solid proton-exchange membrane electrolytes. Trioxane exhibits less crossover than do such conventional fuels as methanol and formaldehyde. Being a solid at ambient temperature, trioxane offers significant advantages in handling and transportation. Trioxane can be synthesized from natural gas with relative ease.

The electro-oxidation of trioxane to carbon dioxide and water is believed to occur according to the reaction

$$(CH_2O)_3 + 6H_2O \rightarrow 3CO_2 + 12H^+ + 12e^-$$

Experiments on the electro-oxidation characteristics of trioxane were performed in half cells with temperature control. The electrolyte was sulfuric acid at various concentrations between 0.5 and 2.0 M. The cells contained gas-diffusion-type electrodes consisting of platinum/tin at an areal density of 0.5 mg/cm_2 on a high-surface-area carbon. The data in Figure 1 indicate that increasing the concentration of trioxane results in an increased rate of oxidation. Current densities as high as 100 mA/cm_2 were realized at potentials of 0.4 V — comparable to the performance realized with formaldehyde.

Cyclic voltammetry showed that the mechanism of oxidation of trioxane does not involve a breakdown to formaldehyde before electro-oxidation. Increasi-ng the concentration of acid was also found to result in increased rates of electro-oxidation. Therefore, it was projected that very high rates of electro-oxidation would occur when using a solid electrolyte of Nafion™ (a commercial perfluorinated, hydrophilic, proton-exchange polymer), which exhibits an acidity equivalent to that of 10 M sulfuric acid.

Experiments on the direct oxidation of trioxane were carried out in a liquid-feed-type fuel cell developed previously for direct oxidation of methanol. In this cell, a Nafion proton-conducting solid-polymer membrane was used as the electrolyte. The membrane electrode assembly included a specially constructed fuel-oxidation electrode made of an unsupported Pt/Ru catalyst layer and a gas-diffusion-type unsupported platinum catalyst for the reduction of oxygen. A fuel solution of trioxane at a concentration of 1 M was circulated past the anode of the cell, while oxygen at a pressure of 20 psi (≈140 kPa) was applied to the cathode. The CO_2 produced by the oxidation of trioxane was separated from the fuel solution in a tall glass column.

Figure 2 shows the current-vs.-voltage characteristics of trioxane in this fuel cell. This performance can be improved considerably by use of platinum/tin electrodes. The measured rate of crossover was found to be no more than 1/5 that in a comparable methanol fuel cell. Decreased rates of crossover are extremely desirable, inasmuch as crossover re-duces the efficiency and performance.

This work was done by George A. Olah, Surya G. Prakash, Sekharipuram R. Narayanan, Eugene Vamos, and Subbarao Surampudi of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 64*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:
William T. Callaghan, Manager
Technology Commercialization
JPL-301-350
4800 Oak Grove Drive
Pasadena, CA 91109

Refer to NPO-19230, volume and number of this NASA Tech Briefs *issue, and the page number.*

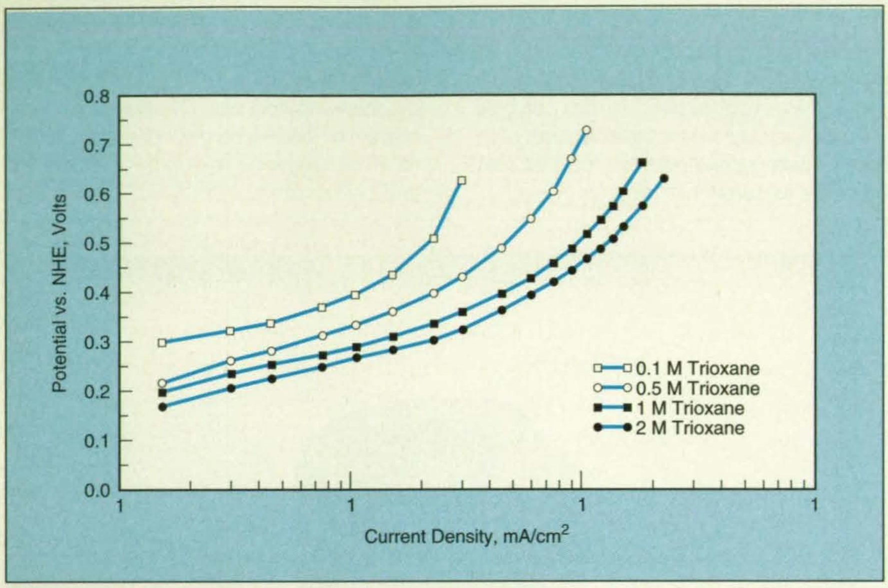


Figure 1. These **Galvanostatic Polarization Curves** show the electro-oxidation characteristics of several concentrations of trioxane at Pt/Sn electrodes of the gas-diffusion type, at a temperature of 55 °C, in a solution with 0.5 M H_2SO_4 and 0.01 M perfluorooctanesulfonic acid (C_8 acid).

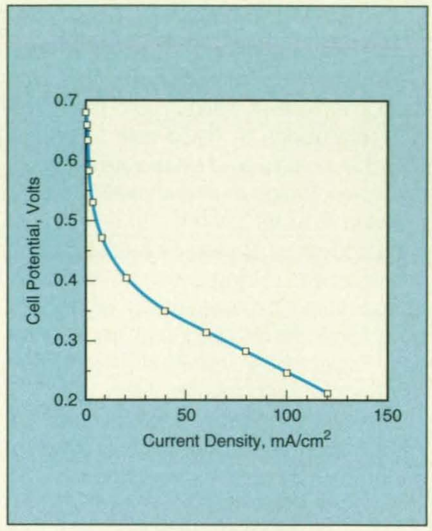


Figure 2. The **Current-vs.-Voltage Characteristics** of a liquid-feed direct-oxidation fuel cell were measured with a 1 M solution of trioxane as the fuel, at a temperature of 60 °C.

Closed-Loop System Removes Contaminants From Inert Gas

The system can be used in place of a supply of purge gas.

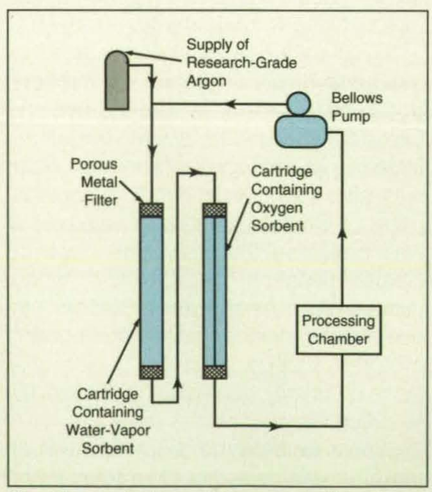
NASA's Jet Propulsion Laboratory, Pasadena, California

A closed-loop system for the purification of an atmosphere of inert gas includes a bellows pump, a cartridge for removal of oxygen, a cartridge for removal of water vapor, and porous metal filters at the ends of the cartridges for removal of particles. These components are connected in series with each other and with a chamber in which the gas is to be used (see figure). In the specific application for which the system was devised, the chamber is one in which semiconducting materials are processed. By virtue of the closed-loop operation, a limited supply of inert gas is adequate to provide an atmosphere for industrial processing of semiconductors.

The rate of leakage of the bellows pump is less than 10^{-6} cm^3/s. All tubes in the system are electropolished and connected together by VCR fittings. Because the gas comes in contact with only metallic parts, the pump does not add new impurities to the gas.

The oxygen-removing cartridge contains a packed oxygen-sorbent material. The cartridge can be heated to a temperature as high as 300 °C for operation in the scrubbing mode or for regeneration of the spent sorbent. Four classes of oxygen sorbents have been developed at NASA's Jet Propulsion Laboratory, each class being best suited for operation in a specific temperature range. These classes of sorbents are (a) copper-exchanged zeolites (200 to 400 °C), (b) copper-modified carbon molecular sieves (room temperature to 250 °C), (c) copper-containing platinum zeolites (100 to 400 °C), and (d) cobalt-containing platinum-modified zeolites (400 to 800 °C).

All of these sorbents take in oxygen by catalytic oxidation of copper. The equilibrium level of oxygen after removal is well below 1 part per trillion at tem-



The **Concentration of Oxygen** in this closed-loop system is kept low by use of a heated catalytic sorbent bed in a cartridge. It is also proposed to keep the concentration of water vapor low by use of a predried zeolite sorbent bed in another cartridge, and to remove particles smaller than 0.1 µm by use of porous metal filters.

peratures up to 400 °C. The oxygen-removing cartridge can be packed with one or a mixture of the oxygen sorbents; the mixture can be tailored, along with the other design parameters, to help adapt the system to meet various design requirements, including temperature of operation, initial level of oxygen impurity, and the like.

The oxygen-removal capability of the system was tested in closed-loop operation, using copper-modified zeolite 13X as the oxygen sorbent. When the sorbent was heated to a temperature of 250 °C, and argon containing oxygen at a concentration of 100 parts per million was introduced, the concentration of oxygen fell, in less than 10 s, to a level below the sensitivity limit (100 parts per billion) of the oxygen-detecting instrument. The rapidity of the decrease in the oxygen level indicates that the ultimate attainable oxygen level is considerably lower than 100 parts per billion.

The water-vapor-removing cartridge was not included in the initial closed-loop tests. It is proposed to remove water vapor by use of pretreated zeolite. The pretreatment would consist in drying the zeolite for 48 h. at a temperature of 300 °C. (The use of zeolite for removal of water vapor is well known.)

This work was done by Pramod K. Sharma of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 60*** *on the TSP Request Card. NPO-18879*

Electrochemical Deposition of Thiolate Monolayers on Metals

The degree of coverage can be controlled with relative ease.

NASA's Jet Propulsion Laboratory, Pasadena, California

An electrochemical method has been devised for coating metal (usually, gold) surfaces with adherent thiolate monolayers. In comparison with older, nonelectrical chemical solution methods, the present electrochemical method affords greater control over the location and amount of material deposited and makes it easier to control the chemical composition of the deposits. One important potential use for this method lies in the fabrication of chemically selective thin-film resonators for microwave oscillators used to detect pollutants: a monolayer can be formulated to bind selectively the pollutant chemical species of interest, causing an increase in mass of the monolayer and a corresponding decrease in the frequency of resonance. Another important potential use lies in selective chemical derivatization for purposes of improving adhesion, lubrication, protection against corrosion, electrocatalysis, and electroanalysis.

A compound used in this method is denoted by the general chemical formula *XRSY*. "*S*" is used here in the standard sense to denote sulfur, which is the component that bonds to the metal substrate. *Y* denotes a group that is lost during deposition, partly because it bonds to *S* less strongly than does the metal substrate; *Y* can represent hydrogen (in which case *XRSY* is a thiol), a

metal (in which case *XRSY* is a thiolate salt), or another organic group.

R is a molecular group that forms somewhat of an isolation layer in that it lies between the *S* moiety attached to the metal and the *X* moiety at the outer end. *R* is chosen to obtain a desired packing density, stability, thickness, and/or other characteristics of the monolayer to suit a specific application. R can be any of a variety of organic groups; for example, a linear alkane chain [$(CH_2)_n$, where *n* is an integer].

R and *X* together determine the characteristics of the deposit. The outer end group, *X*, is chosen to provide the end functionality required in a specific application. *X* end groups that have proven useful include CH_3, $CF_3(CF_2)_7$, COOH, and OH; other potentially useful end groups include inorganic complexes with thiol ligands, organometallic compounds, cyclodextrins, and crown ethers.

In preparation for the deposition process, *XRSY* is dissolved in any of a number of compatible electrolytes; typically, the electrolyte is an aqueous solution of KOH. The process can be carried out in any suitable electrochemical system that includes a voltammetric analyzer and cell assembly. The *XRSY*/electrolyte solution and the working, reference, and counter electrodes of the system are placed in the cell. (The working electrode is the metal substrate to be coated.) The cell is purged with a chemically inert gas to remove dissolved oxygen.

The electrodes are connected to the voltammetric analyzer. For the first 10 to 30 s, the applied voltage is set at a level at which any adsorbed compounds are desorbed so as to clean completely the working electrode, with stirring of the solution to facilitate transport of any desorbed impurities away from the substrate to prevent readsorption. The voltage is then stepped to the deposition voltage, which has been preselected from the anodic deposition wave, to establish a redox equilibrium, thus providing for the desired level of coverage. Typical deposition times range upward from about 1 min.

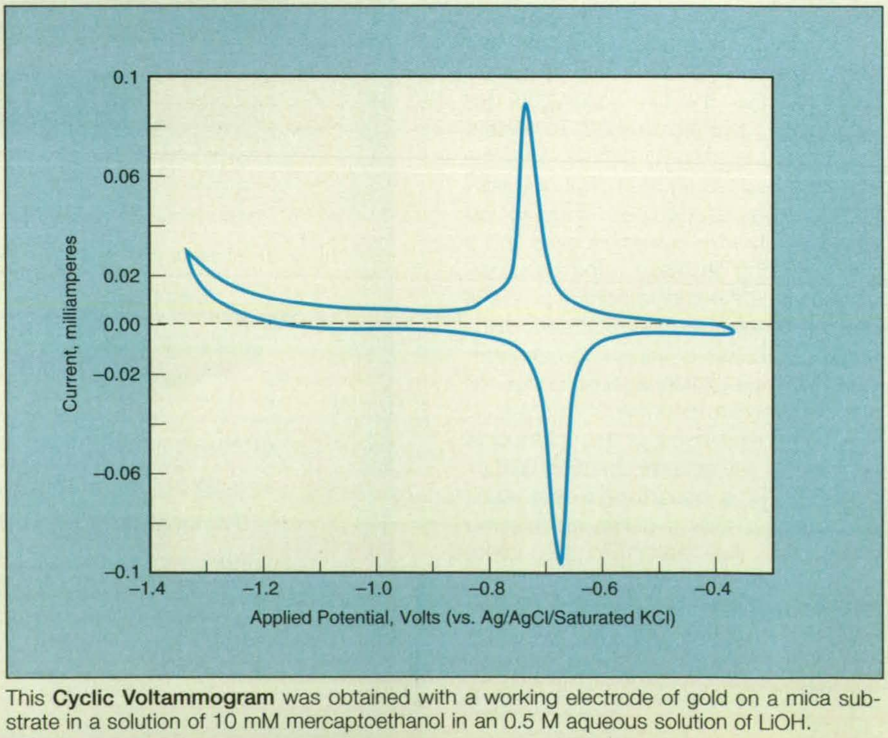
The figure shows a cyclic voltammogram that contains peaks showing the oxidative adsorption and reductive desorption of a layer of the thiolate $HOCH_2CH_2S$– on Au on a mica substrate. This plot shows that the adsorption and desorption processes are well-defined and reproducible.

This work was done by Marc D. Porter and Duane E. Weissharr of Iowa State University for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 88*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

Marc D. Porter, Director
Microanalytical Instrumentation Center
45 Spedding Hall
Iowa State University
Ames, IA 50014

Refer to NPO-19469, volume and number of this NASA Tech Briefs *issue, and the page number.*



This **Cyclic Voltammogram** was obtained with a working electrode of gold on a mica substrate in a solution of 10 mM mercaptoethanol in an 0.5 M aqueous solution of LiOH.

LASER TECH BRIEFS

PORTING THE LATEST FEDERALLY-DEVELOPED PHOTONICS TECHNOLOGY

ASERS

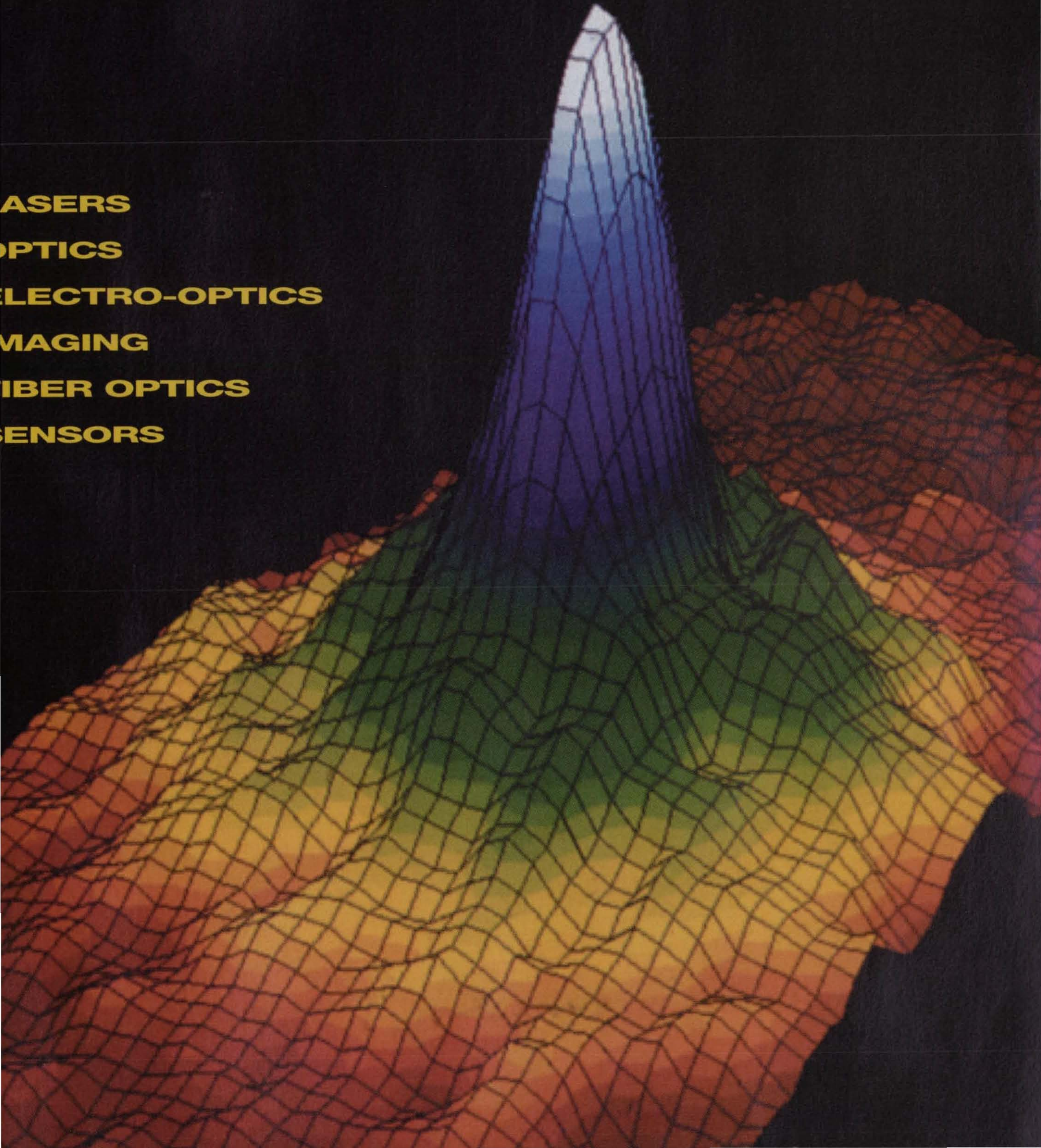
PTICS

LECTRO-OPTICS

MAGING

IBER OPTICS

ENSORS



LASER TECH BRIEFS

Federal Lab Laser Tech Briefs Supplement to *NASA Tech Briefs* October 1995 Issue Published by Associated Business Publications

LASER TECH BRIEFS

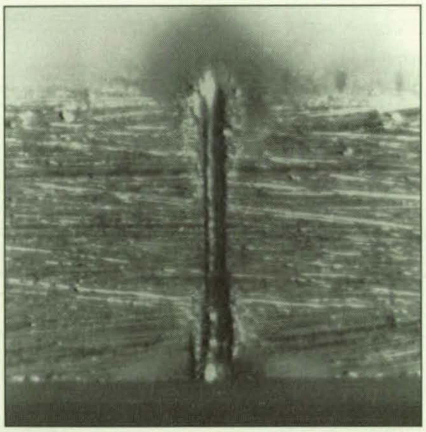
DEPARTMENTS

On the cover:
A three-dimensional isometric plot of the atomic velocity distribution in a "Bose-Einstein condensate" achieved by a group of scientists from NIST, the University of Colorado, and JILA. Using laser trapping, followed by magnetic trapping, the group got the rubidium-87 atoms in a dilute gas down to 170 nanokelvins. There the peak indicated a cluster of atoms "frozen" into a stationary quantum state, and acting like a single atom, as predicted independently in 1924 by Albert Einstein and Indian physicist Satyendra Nath Bose. *Photo by Mike Matthews/University of Chicago, courtesy of* Science News.

News Briefs

Notes from Industry and the Federal Laboratories

In tests conducted for 3M and Owens-Corning, researchers at the University of Michigan's Center for Ultrafast Optical Sciences (Ann Arbor) recently drilled a hole 25 microns in diameter through a stainless steel plate 0.5 mm thick using a 160-fs pulsed Ti:sapphire laser with a repetition rate of 1 kHz. It took about half a minute to perform the operation. UM scientist Peter Pronko says the technique can also be used to drill sub-wavelength and sub-spot-size holes in many materials. Experiments have been done on a variety of metals, glasses, and plastics. In semiconductor manufacturing the method could create channels, layers, and holes in a silicon wafer without damaging films or circuitry. Focused inside transparent materials, the laser could carve out internal structures without making holes in the surface. UM researchers say the method could increase the capacity of CD-ROMs and other data storage devices. UM has applied for a patent on the micromachining technique. Research at the Center is funded by the National Science Foundation.



A hole 35 microns in diameter drilled by a pulsed Ti:sapphire laser in a stainless steel plate at the University of Michigan's Center for Ultrafast Optical Sciences. Photo courtesy Xinbin Liu, Univ. of Michigan.

FCI Environmental Inc. and EG&G Energy Measurements, both of Las Vegas, NV, will collaborate to develop rugged miniature fiber optic sensors to monitor the environment for petrochemicals and other pollutants. The cooperative agreement involves EG&G technology originally created to support the Department of Energy's nuclear weapons testing program. With it, said Geoff Hewitt, FCI's president, the company will be able to build sensors that can be placed in remote locations for long periods of time to detect a variety of chemicals and hazardous toxins. FCI, a wholly owned subsidiary of FiberChem Inc., developed the first commercial fiber optic chemical sensor to detect and quantify petroleum hydrocarbons in air or water in real time.

Formally announced in July, OptoSigma Corp. (Santa Ana, CA), a new company, brings together a group of US optical-industry veterans led by Paul Kenrick, formerly of Melles Griot US, and Sigma Koki Co., a Japanese manufacturer of electro-optical and laser components. "We will offer a broad-based catalog of laser-quality optical components and optomechanical products," Kenrick says, "backed by the best technical support." Sigma Koki plans to invest in a modern production facility in the US. OptoSigma will offer "items selected from around the world" to complement its own product range. The company is located at 2001 Deere Ave., Santa Ana 92705; (714) 851-5881; (714) 851-5058.

Newport Corp. (Irvine, CA) has announced it will be the exclusive distributor of LightPath Technologies Inc.'s (Tucson, AZ) standard catalog and custom products using its patented GRADIUM material for all laser/electro-optic and semiconductor applications. GRADIUM lenses are the first commercially available components that use the material, which has a refractive-index gradient along the optical axis, eliminating spherical aberration. Made up of glass layers diffused into a single piece, the lenses can be produced in much larger sizes than standard GRIN rod lenses or molded aspheres, LightPath says. Twelve-mm and 25-mm positive and negative lenses are now available from Newport.

The Richardson Grating Laboratory (Rochester, NY) has been sold to Life Sciences International plc (LSI) of London, England, and is now an operating unit of Spectronic Instruments. The Laboratory, which designs and fabricates ruled and holographic diffraction gratings for the research and commercial optics markets, became part of Milton Roy Co. in 1985; Milton Roy later became a subsidiary of Sundstrand Corp. The analytical instrumentation businesses of Milton Roy are included in the LSI purchase. With 1994 sales of $273 million, LSI is an international supplier and manufacturer of scientific equipment for laboratories. Among its other operating units in the United States is NESLAB, the Portsmouth, NH, manufacturer of recirculating chillers.

MicroE Inc. (Needham Heights, MA) has purchased the diffractive-optics-based microencoder business of BEI Electronics Inc. (San Francisco, CA). MicroE was formed by CEO Don Mitchell, with funding from Massachusetts and Pennsylvania venture capital firms and private investment, to develop the patented scale-based interferometric linear and rotary position sensor technology formerly owned by BEI. Mitchell invented the MicroEncoder, a device based on physical optics for measuring linear or rotary motion. According to Mitchell, the MicroEncoder offers accuracy comparable to conventional laser interferometers at much lower cost and in a much smaller size. MicroE is located at 130 A St., Needham Heights 02194; (617) 455-1414; FAX (617) 455-6514.

Coherent Inc. (Santa Clara, CA) and Uniphase Corp. (San Jose, CA) entered into a patent license agreement and an asset purchase agreement. Uniphase obtained a limited nonexclusive sublicense on the Sipes patent, assigned to Coherent by Amoco, the original corporate holder, and covering the technique of focusing the output of a diode pump laser into the solid-state lasing medium. In exchange for this, Coherent acquired the assets of Uniphase's Torrance, CA, diode laser operation. Kevin Kalkhoven, president of Uniphase, said the patent technology will materially aid the company's development of green and blue solid-state microlasers. For Coherent, said Bernard Couillard, general manager of the Laser Group, the addition of diode laser technology to its diode-pumped solid-state business, recently buttressed by the acquisitions of Adlas GmbH and Amoco's non-telecommunications assets, would strengthen its position in the medical and OEM markets.

Digital Instruments (Santa Barbara, CA) has established an Internet "mailing list" for scanning probe microscopy (SPM) users. It calls the list "an open and unedited forum for discussing and exchanging technical information, views, issues, and applications of SPM...." Those who wish to subscribe should send a line similar to the following to majordomo@di.com: "subscribe spm <your E-mail address>." Instructions for use are provided on log-in. Once subscribed, the user may submit articles to spm@di.com. The company also offers a Home Page at http://www.di.com, which includes applications information, support hints, bibliographies and information on products and services.

Edmund Scientific Co. (Barrington, NJ) dedicated the new $1.2-million 19,000-sq.-ft. "Pauline Edmund Wing" at a ceremony July 31. President Robert M. Edmund said the two-story structure was named to recognize the great contribution made to the company by his mother, who served for some 30 years as vice president of operations. He noted that "based on our sales growth for the past five years, the new addition will take care of the present expansion needs while satisfying a projected growth five years from now." Edmund's work force has increased by 60% to 160 in the past decade, as its product offerings and its familiar 236-page catalog expanded to encompass a wide selection of optical components and instruments, scientific instruments, and educational aids. New Jersey Congressman Robert E. Andrews was the keynote speaker at the ceremony.

A Field Medical System Using a Laser Diode

The portable unit makes incisions, stops bleeding, and closes wounds.

USAF Phillips Laboratory, Kirtland Air Force Base, New Mexico

A medical laser system developed at USAF Phillips Laboratory is a very compact device that provides the field paramedic or physician with a unique portable battery-operated medical capability. The laser system is able to cut like a scalpel, coagulate bleeding, and close wounds.

Emergency medical system physicians and battlefield medics have a similar need to improve emergency wound procedures to reduce treatment time and trauma to the victim. Phillips Laboratory's MedPac consists of a completely self-contained system based on a laser diode and operated by a rechargeable battery. The laser energy is delivered by a fiber optic cable that provides the very high power density necessary at the tip to cut and cauterize tissues.

The system dimensions are 3" X 7" X 9" and its weight is eight pounds; it will easily fit into a small beltpack. It is powered by one rechargeable sealed lead-acid battery. A recharging port is also provided, as is a key lock for safety and security. If the system is used in a beltpack, only the optical fiber will extend from the pack. The laser light at the tip of the fiber is very intense: one kilowatt per square centimeter. Several standard disposable sterile medical tips are available that can be directly applied to the wound and are being evaluated for cutting and coagulation.

The most important electronic element in the MedPac is the high efficiency constant-current laser driver. This driver uses the latest DC-to-DC converter technology combined with extremely low-resistance power MOSFETs to provide a compact, efficient package that is ideally suited for battery-powered field devices. Typical efficiency is greater than 82% for load currents up to 30 A. This helps reduce energy losses due to heat generation in the laser driver, and also extend battery life.

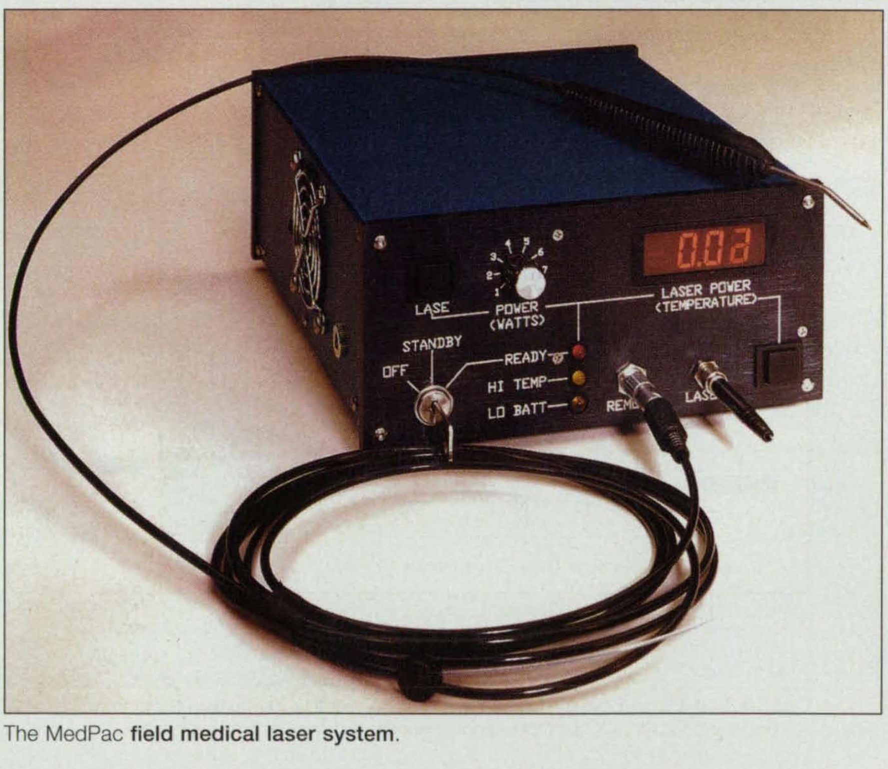
An important requirement for driver circuits is that they accurately regulate the current flowing through the laser. The current variation for this device is typically less than 1% as the input is varied between 9 and 15 V. Current overshoot at turn-on is less than 0.5%.

DC-to-DC converter technology helps to reduce the current drain on the battery power source. The supply current is reduced by approximately the ratio of V_{in}/V_{out}. In the present application, which uses a 12-V battery, the battery supplies 3.5 A for a laser drawing 20 A at 2.0 V. This improves efficiency by a factor of 6 over a circuit using a voltage regulator to reduce the input voltage to the level required by the laser. A 12-V 4.6-A/hour battery provides approximately 60 minutes of maximum power from the laser.

The laser driver also has a unique feature that allows it to utilize nearly 100% of the available battery energy. The internal low-dropout current regulator will keep the laser current constant until the battery voltage drops below 3.8 V. This provides a longer useful run time per battery charge.

The MedPac control unit is made up of three functional parts. These are the thermal-electric (TE) cooler controller, a signal-conditioning circuit for the display, and a temperature watchdog circuit.

The TE cooler circuit is made from a thermistor circuit and a switching current supply. The thermistor has a constant current flowing through it that is used to set the idle temperature of the laser. The voltage across the thermistor is fed into the switching current supply, which drives the cooler. The current supply has three modes of operation: on (not switching), on (switching), and off. When the laser temperature is above 17 °C the cooler circuit is turned completely on (non-switching). It supplies 2.5 A to the cooler and draws 2.5 A. When the laser temperature reaches 15 °C the circuit starts to switch, supplying 2.0 A and



The MedPac **field medical laser system**.

drawing 0.6 A. As the laser reaches 14 °C the circuit turns off. The laser temperature at system idle is between 14 °C and 15 °C. The system is 90% efficient when in the switching state, and draws less than 300 µA in the idle state.

The front-panel display has the ability to show either the laser's temperature or output power. The power is derived from the laser's current. This is only a rough estimate, because the power varies over temperature and the laser is set up to have a running temperature between 15-30 °C. It is read from a current-sensing resistor on the laser current supply board. Both the temperature and power signals are fed into the digital panel meter.

The temperature watchdog circuit will shut off the laser's power supply when it reaches a high temperature of 30 °C and will re-enable the laser power supply when the temperature falls below a setting of 25 °C. The input temperature signals are derived from a thermistor.

Clinical research examined the medical viability of the Field Medical Laser System. Tests were conducted with the MedPac at the University of Illinois School of Medicine in altitude chambers, and on-board aircraft from the 126th Air National Guard, O'Hare Field, Chicago. Two different procedures, cutting and coagulation, were conducted with the MedPac and compared with two other medical instruments, the scalpel and the CO_2 medical laser system. The tests indicated that the MedPac can function in various ground and air environments ranging from Arctic, tropics, and pressurized flight environments.

In conjunction with the Medical School, environmental and altitude chamber tests followed a matrix that included standard day, Arctic (18 °C, 20% humidity), tropical (100 °C, 100% humidity), and flight (60 °C, 7000 ft., pressurized). Both lasers, CO_2 and diode, can be varied up to 9 W of output power, but were set to operate at 5 W. The results were as follows:

- Standard day: scalpel cut (1 cm) 2 seconds; CO_2 3 seconds; MedPac 3 seconds;
- Arctic environment: scalpel cut 2 seconds, CO_2 4 seconds; MedPac 3 seconds;
- Tropical environment: scalpel cut 2 seconds; CO_2 3 seconds; MedPac 2 seconds;
- Flight environment: scalpel cut 2 seconds; CO_2 3 seconds; MedPac 3 seconds.

The resulting times for the incisions were not as important as the conditions of the cuts. However, the important outcome of these particular tests is that the MedPac laser provided a clean, bloodless incision.

MedPac, the Field Medical Laser System, provides the physician with a lightweight, portable surgical laser tool that can produce immediate coagulation and closure of wounds. This results in less loss of blood, an improved view of the wound site, and better control of patient care, thereby sustaining homeostasis. Furthermore, with the advent of diode laser technology, other applications are surfacing that allow for advanced battlefield trauma care, as well as patient stabilization in civilian care. These include wound sterilization, bacteriology, and tissue welding.

This work was done by Michael Allen, Mark Gaddis, Dan Garber, Doug Webb, John Kelly, and Michael Colvard for **US Air Force Phillips Laboratory.** *A patent is pending. The group wishes to acknowledge one of the inventors, Capt. Andy Keipert, for his dedication to the Field Medical Laser System Program.*

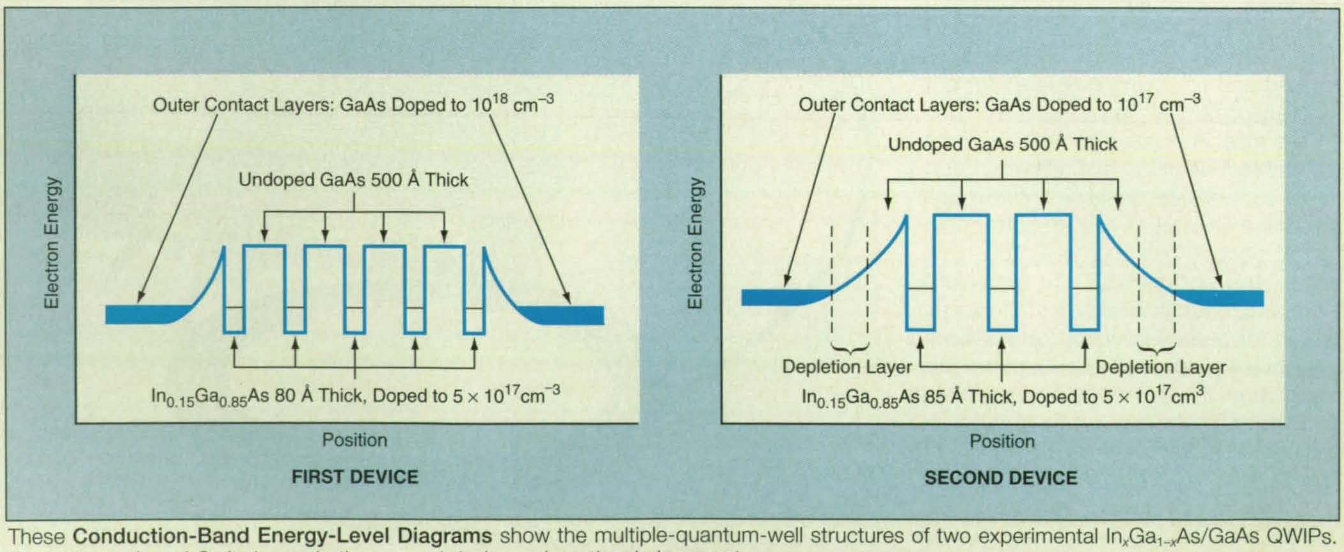
Inquiries concerning rights for commercial use of this invention should be addressed to Michael S. Allen, USAF Phillips Laboratory, PL/LIDA, 3550 Aberdeen Ave. SE, Kirtland AFB, NM 87117-5776; (505) 846-7034; FAX (505) 846-4313. Alternatively, inquiries may be directed to the Alliance for Photonic Technology, 851 University Blvd. SE, Bldg. 1, Suite 200, Albuquerque, NM 87106-4339; (505) 272-7001.

$In_xGa_{1-x}As/GaAs$ Quantum-Well Infrared Photodetectors

Detectivities of experimental devices were found to be comparable to those of $Al_xGa_{1-x}As/GaAs$ devices.

NASA's Jet Propulsion Laboratory, Pasadena, California

The first infrared photodetectors that operate at wavelengths as long as 18 µm have been made with multiple-quantum-well structures that consist of quantum-well layers of $In_xGa_{1-x}As$ alternating with non-lattice-matched quantum-barrier layers of GaAs. Heretofore, quantum-well infrared photodetectors (QWIPs) have been made with quantum-well layers of



These **Conduction-Band Energy-Level Diagrams** show the multiple-quantum-well structures of two experimental $In_xGa_{1-x}As/GaAs$ QWIPs. The outer undoped GaAs layers in the second device reduce the dark current.

GaAs alternating and lattice-matched, variously, with quantum-barrier layers of $Al_xGa_{1-x}As$, $Ga_{0.5}In_{0.5}P$, or $Al_{0.5}In_{0.5}P$. Note that GaAs is the well material in the older devices and the barrier material in the present devices.

The choice of materials for the present QWIPs was affected principally by two considerations. One was that in comparison with GaAs, $In_xGa_{1-x}As$ is potentially a superior quantum-well material because of its stronger absorption of infrared radiation. The other consideration was that in comparison with $Al_xGa_{1-x}As$, which is the usual barrier material in the older devices, GaAs is potentially a superior barrier material because it exhibits superior transport properties (lower scattering and higher mobility of charge carriers).

The figure illustrates the quantum-well layer configurations of two experimental QWIPs made of $In_{0.15}Ga_{0.85}As$/GaAs. The first device contains five 80-Å-thick $In_{0.15}Ga_{0.85}As$ quantum-well layers doped to 5×10^{17} cm^{-3}, separated by 500-Å-thick quantum-barrier layers of undoped GaAs. The outer contact layers are made of GaAs doped to 10^{18} cm^{-3}: unlike in older QWIPs, the heavily doped contacts are made of the higher-band-gap GaAs semiconductor — in this case, GaAs. This is quite different from the $Al_xGa_{1-x}As$/GaAs heterosystem, in which the GaAs is the low-band-gap quantum-well and contact material.

This reversal of roles is necessary because a thick contact layer of the strained, non-lattice-matched $In_{0.15}Ga_{0.85}As$ would contain too many defects and threading dislocations. The design of the first device makes use of the strong bending of the energy band in the region between the heavily doped GaAs contact layers and the first and last $In_{0.15}Ga_{0.85}As$ quantum wells. This results in a large quantum-mechanical-tunneling current, which essentially short-circuits the first and last wells, thus effectively making contact with the low-band-gap material. The active quantum-well structure therefore consists of the middle three quantum wells.

The second device contains three 85-Å-thick $In_{0.15}Ga_{0.85}As$ quantum-well layers doped to 1×10^{17} cm^{-3}, interspersed with four 500-Å-thick quantum-barrier layers of undoped GaAs. The outer contact layers are made of GaAs doped to 1×10^{17} cm^{-3}. It is worth noting that unlike the first device, this device contains undoped GaAs spacer layers between the outermost quantum well and the outer contact layers: as a result, the tunneling injection current from the contacts to the quantum wells should be significantly smaller than it is in the first device. Therefore, the dark current of the second device should be smaller, resulting in higher detectivity.

Experiments have confirmed that the dark current of the second device is much smaller than that of the first device at temperatures below 60 K. The spectral responsivities of the devices were measured at 40 K with a bias of 100 mV: For the first and second devices, the responsivities peak at wavelengths of 15.3 and 18 μm, respectively, while both devices reach their long-wavelength (half-peak) cutoffs at 18.3 μm. The detectivities of both devices increase with decreasing temperature: at 10 K, the detectivities of the first and second devices were found to be 8.0×10^9 $cm \bullet Hz^{1/2}/W$ and 9.7×10^{10} $cm \bullet Hz^{1/2}/W$, respectively — comparable to the detectivities of $Al_xGa_{1-x}As$/GaAs QWIPs.

This work was done by Sarath D. Gunapala, Jin S. Park, True-Lon Lin, and John K. Liu of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 69*** *on the TSP Request Card. NPO-19323*

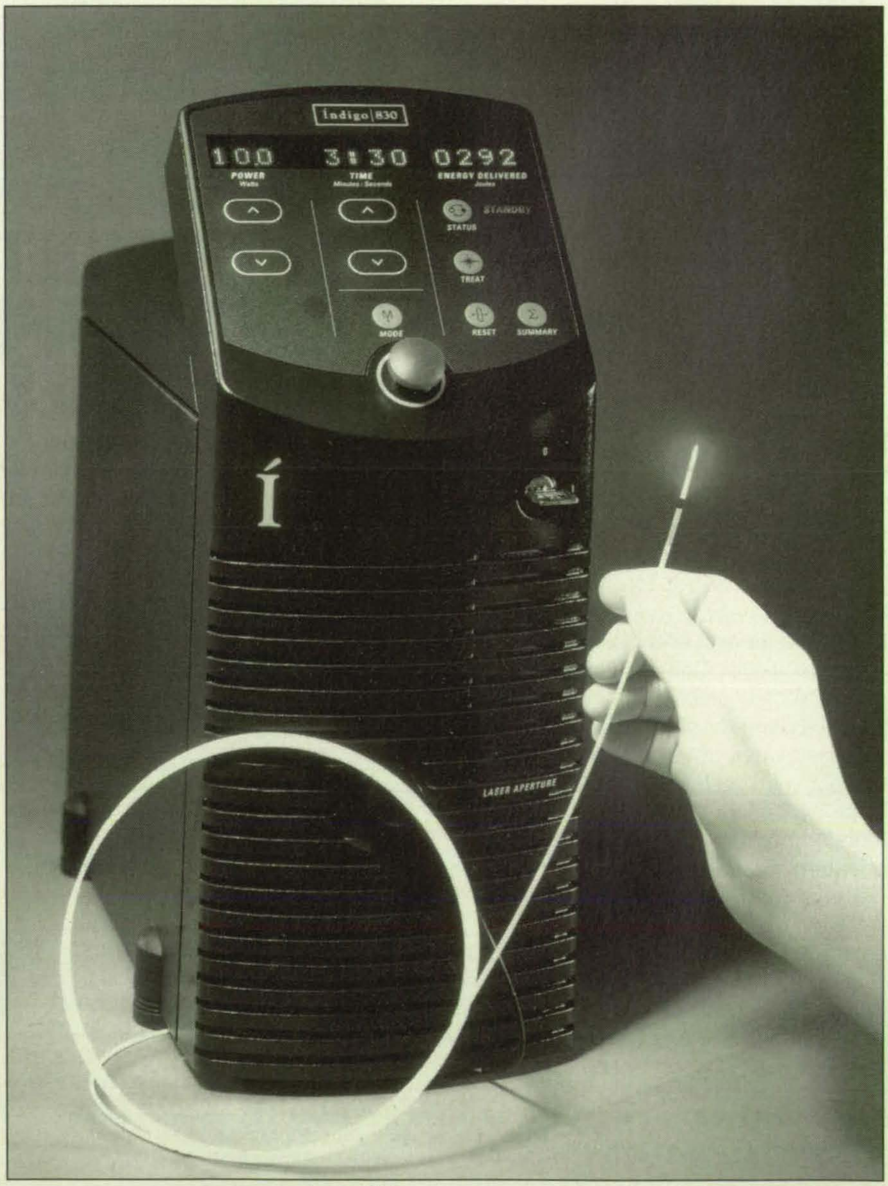
New Laser Treatment for Enlarged Prostate

A diode laser device could result in a cost-effective, safer, and less painful treatment.

Inhalation Toxicology Research Institute (ITRI), Albuquerque, New Mexico

Enlarged prostate (benign prostatic hypertrophy) is a common disease affecting up to half of all men over the age of sixty. As the part of the prostate gland around the urethra increases in size with advancing age, the urethral opening decreases, resulting in difficult urination and urine retention in the bladder. Symptoms include frequent urination, discomfort, urinary-tract infections, and in severe cases, urinary tract obstruction. Treatment is directed at reducing the prostatic tissue surrounding the urethra. Hormone treatment sometimes succeeds, but most treatments involve destroying the prostatic urethra and tissues by surgical excision or laser coagulation necrosis via the urethra. Both require several days of hospitalization; in addition, laser treatment uses fairly expensive equipment.

ITRI is collaborating with Índigo™ Medical, Inc., of Palo Alto, CA, to demonstrate a new treatment procedure in



Development and testing of the Índigo™ 830 **portable diode laser** may lead to effective interstitial thermotherapy for chronic enlarged prostate.

which a small fiber attached to a diode laser is placed directly into the prostate to necrotize tissue. The laser costs much less and is safer to operate than the Nd:YAG lasers typically used in laser coagulation necrosis. Because it delivers its energy more slowly, it is easier to control. Moreover, unlike current approaches, interstitial thermotherapy does not destroy the urethra, which can lead to significant pain, increased risk of bleeding, and need for transfusions.

This work began as a collaboration between Air Force Phillips Laboratory, Los Alamos National Laboratory, and Índigo™ Medical, Inc., to design a prototype laser and fiber that could be used in tissue. The collaboration continued, under the direction of Dr. Bruce Muggenburg at the **Inhalation Toxicology Research Institute**, *as the system was evaluated. The treatment is now being further evaluated in clinical trials. Patents are pending.*

Inquiries regarding use of the treatment can be directed to Dr. Horst Adam, Índigo™ Medical, Inc., 1049 Elwell Court, Palo Alto, CA 94303, or Dr. Charles H. Hobbs, Inhalation Toxicology Research Institute, PO Box 5890, Albuquerque, NM 87185; (505) 845 1037; FAX (505) 845-1198.

Measuring Pixel-Position Errors on CCD Imagers

Interference fringes are used as a reference pattern.

NASA's Jet Propulsion Laboratory, Pasadena, California

Deviations of the positions of pixels on a charge-coupled-device (CCD) image detector from a nominal rectangular grid pattern can be measured by a method in which coherent-light interference fringes are used as a reference pattern. These deviations are attributed, at least in part, to imperfections in step-and-repeat machinery used to generate the grid patterns in manufacturing. The method was conceived for use in determining pixel-position errors in astrometric cameras to be flown aboard spacecraft. The method can also be applied to the determination of similar errors in (and calibration of) terrestrial CCD cameras used as position sensors; for example, position-measuring cameras that are parts of robotic systems.

Figure 1 illustrates schematically how the interference fringes are formed on the CCD and measured. Light from a helium/neon laser is coupled into a single-mode optical fiber that is split into two single-mode optical fibers at a directional coupler. The other ends of the two fibers are held a few millimeters apart in an aluminum block. The ends of the fibers lie on the surface of the block that faces the CCD, with their optical axes perpendicular to this surface. This surface is polished to make it reflective so that the optical axes can be aligned perpendicular to the face of the CCD by use of an ancillary technique that involves observation of multiple reflections of a laser beam.

The ends of the fibers are held at a distance of about 1 m from the CCD, so

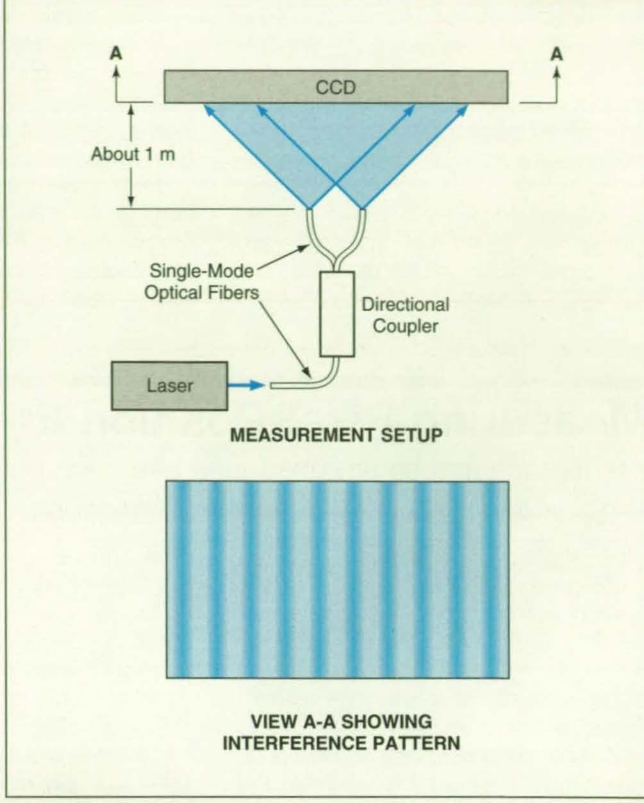


Figure 1. **Interference of Laser Beams** emerging from the two optical fibers forms a fringe pattern that is used as a reference grid.

that in the case of a CCD of typical dimensions, the spatial interval between successive interference fringes is about 20 pixels. The fringe spacing, the polarization of the laser light, and the orientation of the fringes in the CCD plane are not critical; it is not even necessary to suppress jitter because the effects of fluctuations on the readouts of the pixels are suppressed by integrating the readouts over exposure times of a few seconds. In addition to the exposure taken with interfering light from both fibers, an exposure is taken with light from each fiber alone; these single-fiber exposures provide calibration data that are used to correct for spatial variations of the intensities of the beams from the fibers when analyzing the readouts from the two-fiber exposure by the technique described next.

The time-integrated CCD readouts from the two-fiber exposure are digitized, corrected for beam spatial variations, and compared with the corresponding computer-generated data on ideal interference fringes. The global fringe spacing, orientation, phase,

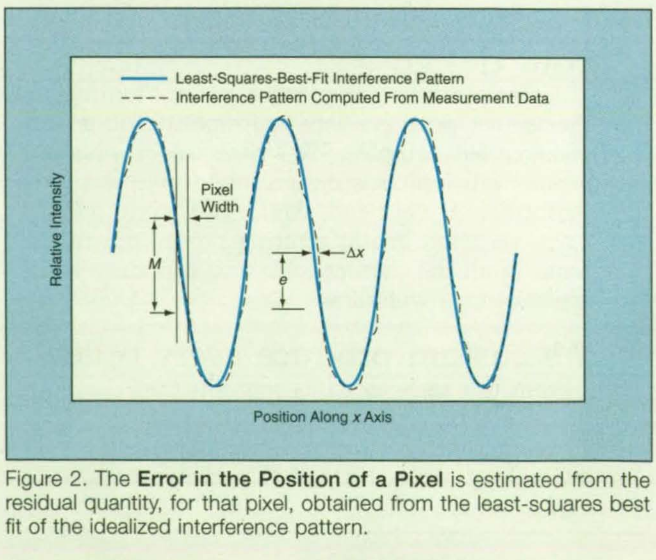


Figure 2. The **Error in the Position of a Pixel** is estimated from the residual quantity, for that pixel, obtained from the least-squares best fit of the idealized interference pattern.

amplitude, and modulation of the actual interference pattern are deemed to be those of whichever computer-generated pattern best fits the measurement data according to the method of least squares.

The residual (error) quantities of the least-squares best fit are due to (1) poor quantum-efficiency calibration, (2) subpixel gradients in illumination and/or sensitivity, and/or (3) the pixel-position errors that one seeks to determine. The effects of quantum-efficiency calibration errors can be suppressed by taking many single-fiber exposures. The effects of intrapixel gradients can be suppressed by making the fringe spacing much larger than a pixel, and preferably at least 10 pixels; this is the reason for the choice of the 20-pixel fringe spacing mentioned above.

The remaining residual quantities can thus be attributed to pixel-position errors; the position error, Δx, for each pixel is estimated from $\Delta x = e/M$, where e is the residual quantity for that pixel and M is the gradient (change per unit pixel width) of the idealized interference pattern at the nominal position of the pixel (see Figure 2). The position errors are thus estimated only in the neighborhoods that contain the maximum gradients of the idealized interference pattern; a map of position errors across the entire CCD is obtained by piecing together maps made from fringe patterns with different phases.

This work was done by Stuart B. Shaklan, Mike Shao, Yekta Gursel, and Jeffrey Yu of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 44*** *on the TSP Request Card. NPO-19419*

A Continuous Emissions Monitor for Metals

Laser-spark spectroscopy (LASS) is the basis for a prototype system.

Sandia National Laboratories, Livermore, California

One of the greatest challenges in gaining approval to operate hazardous waste treatment plants is convincing the public and regulators that the effluent from the treatment process will be free of toxic compounds. Continuous monitoring of the effluent stream could provide the necessary assurance, but suitable monitors are not available to do such measurements of many common pollutants, including metals.

Currently, stack emissions of toxic metals are measured using extractive sampling followed by off-line batch chemical analysis. This largely manual procedure is costly, introduces sampling errors, and typically has turnaround times of days or weeks, making continuous assurance impossible.

The Department of Energy's Sandia National Laboratories is developing a laser-based instrument that continuously monitors metals in a flow *in situ*, eliminating the need for sample extraction. The instrument would not only provide environmental assurance, but also would eliminate the potential for sampling errors and provide data that could be used for on-line control of metal emissions.

The Sandia monitor is based on an advanced optical technique called laser spark spectroscopy (LASS). In this technique, a high-power pulsed laser is focused in the effluent stream. The high energy density in the focal region generates an optical breakdown, commonly called a laser spark or laser induced plasma, in which particles and molecules are decomposed into excited atoms and ions. The variation of the

intensity of light emitted by these excited species correlates directly with the type and quantity of metal present.

Because the monitor relies on the measurement of optical output resulting directly from laser input, measurements can be performed *in situ*, with both input and output transmitted through windows in the exhaust duct transporting the effluent. A major advantage of the LASS technique is that it can measure metals embedded in particles or in liquid aerosols, which account for most of the metals emitted from hazardous waste treatment processes.

Sandia's transportable continuous emissions monitor (CEM) is suitable for in-plant application. The prototype consists of three basic components: (1) an optical probe, shown schematically in the figure; (2) rugged instrumentation racks that contain a spectrometer, detector, and control instrumentation; and (3) a personal computer for data acquisition and control.

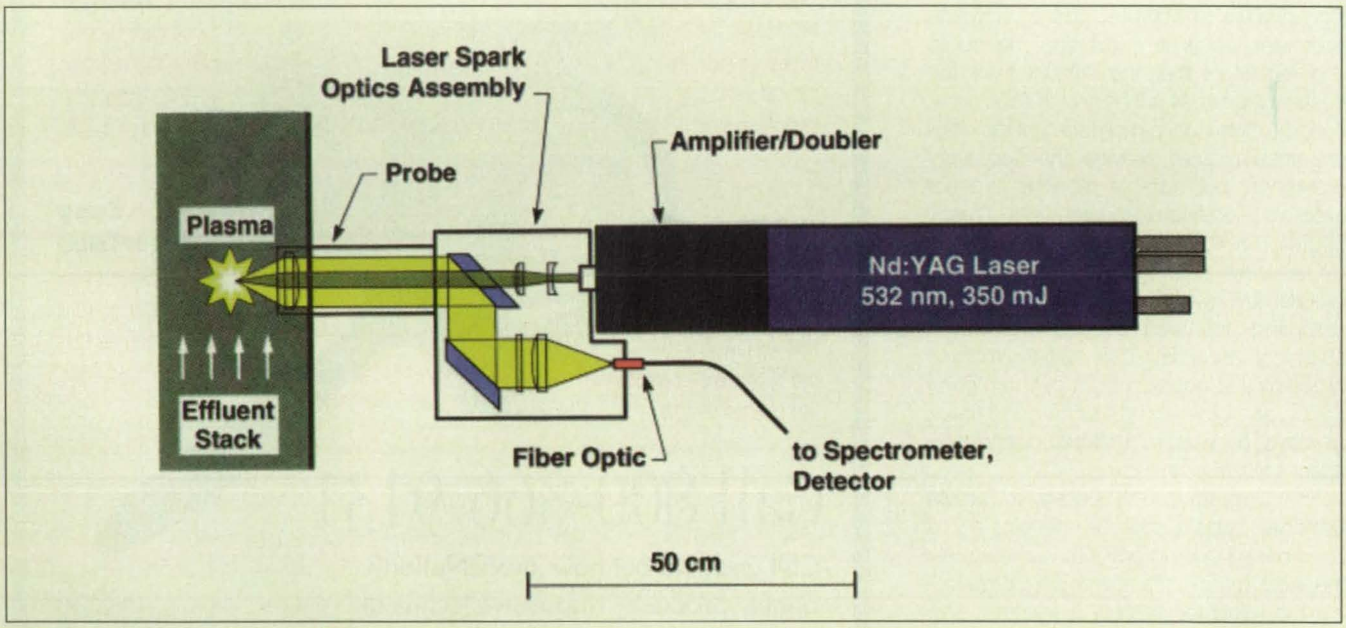
The optical probe unit contains a pulsed Nd:YAG laser plus focusing and collection optics. Frequency-doubled (532-nm) Q-switched laser output is expanded and collimated by a pair of lenses and then is focused in the effluent stream by a third lens. The final laser-focusing lens also serves to collect and collimate a portion of the optical emission from the laser-induced breakdown. This emission is focused on the tip of a fiber-optic bundle, which transmits the plasma emission to the instrumentation-rack-mounted spectrometer and detector. The prototype monitor is controlled remotely by a personal computer, which also analyzes measured optical-emission spectra to determine metal concentrations in real time.

The prototype CEM was successfully demonstrated at DOE funded pilot-scale waste-treatment facilities in South Carolina and Idaho. These tests showed that hazardous metals can be measured in the effluent from thermal-treatment facilities that are processing metal-containing wastes. This was the first demonstration of the ability of a laser-spark CEM to determine metal concentrations through analysis of individual spectral lines in a complex "real" effluent, where numerous spectral features from nonregulated species were also present. Well-isolated spectral lines of regulated metals were identified and analyzed, even in the presence of large abundances of interfering species. The measurements also provide the first real-time insight into how emissions change as system operating parameters are changed. An advanced prototype will be demonstrated at a full-scale thermal treatment facility in 1996.

In addition to the application to hazardous waste treatment facilities, the LASS metals monitor has potential commercial application to a wide variety of other sources, including fossil-fuel power plants, industrial furnaces and boilers, electroplating facilities and semiconductor manufacturing processes.

This work was done at **Sandia National Laboratories** *under the sponsorship of the Dept. of Energy Office of Technology Development's Characterization, Monitoring, and Sensors Technology Crosscutting Program. For further information, contact Bill Flower, Principal Investigator, MS 9103, Sandia National Laboratories, Livermore, CA 94551 0969.*

Inquiries regarding rights for the commercial use of this device should be directed to C.V. Subramanian, Manager, Licensing, Sandia National Laboratories, Livermore, CA 94551-0969.



Schematic diagram of the **optical probe** used as a continuous emissions monitor for metals.

Micromachined, Electrostatically Deformable Reflectors

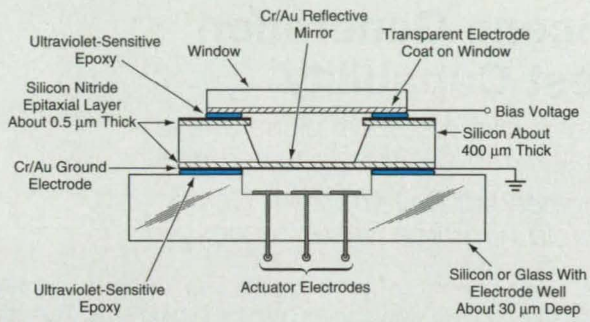
Beam-control reflectors could be integrated with electronic control circuits.

NASA's Jet Propulsion Laboratory, Pasadena, California

Micromachined, closed-loop, electrostatically actuated reflectors (µCLEARs) are being developed to provide relatively simple and inexpensive alternatives to the large, complex, expensive adaptive optics used to control wavefronts of beams of light in astronomy and in experimental laser weapons. The development of µCLEARs may not only overcome some of the disadvantages and limitations of older adaptive optics but may also satisfy demands of a potential market for small, inexpensive deformable mirrors in electronically controlled film cameras, video cameras, and other commercial optoelectronic instruments.

Micromachining can be used to make a deformable mirror, its supporting

structure, and actuation circuitry. The actuation circuitry can include electrostatic-actuator electrodes, sensing electronics, drive circuits that apply electrostatic-deflection voltages to the actuator electrodes, and control circuits. The actuation circuitry can be fabricated on the same silicon wafer that contains the supporting structure; this integration minimizes electrical noise and results in a compact, lightweight, inexpensive, electrically and optically sensitive adaptive optic that is relatively insensitive to environmental effects. Typically, the deformable mirror is



Electrostatic Attraction between the flexible mirror and each of the electrodes varies with the voltages applied to the electrodes. Thus, the applied voltages can be varied to deform the mirror to a desired shape. A typical practical μCLEAR would contain more than the three actuator electrodes shown here.

made from a separate piece of silicon or other material and attached to the supporting integrated circuit structure.

The figure illustrates the configuration of a basic prototype μCLEAR without integrated actuation circuitry. This μCLEAR includes a micromachined mirror mounted on a micromachined silicon frame. The mirror can be a thin film as shown here or it can be thicker — even as thick as the frame, depending on the required stiffness of the mirror. The mirror is electrically grounded and aligned above a planar array of actuator electrodes, forming an array of parallel-plate capacitors. A window that holds a transparent electrode is mounted in the front of the mirror surface.

A bias voltage applied to the transparent electrode moves the mirror into a preload deformation position away from the array of actuator electrodes. Application of a voltage to an actuator electrode results in electrostatic attraction between that electrode and the mirror, resulting in a deformation, concentrated in the vicinity of that electrode, of the mirror toward that electrode. The capacitances between actuator electrodes and a mirror can be exploited to obtain capacitive feedback indicative of the distances between the electrodes and the mirror and thus indicative of the state of displacement or deformation of the mirror. The capacitive displacement feedback from each actuator electrode eliminates the need for costly and complex optical deformation feedback, and enables more accurate position control than can be obtained from conventional open-loop systems.

Electrostatic actuation can be achieved at powers and voltages smaller than those of piezoelectrically actuated adaptive optics. The thicknesses of mirrors and structural boundary conditions can be widely varied among μCLEAR designs to obtain deformations in various preferred modes. Actuator electrodes can be laid out in specified patterns to achieve the desired deformations with minimum numbers of electrodes and simplified control algorithms and electronics. Closed-loop electrostatic actuation can be combined with advanced control algorithms that take into account the nonlinear structural behaviors

of mirrors. For example, layouts of actuator electrodes, control algorithms, and actuation circuits can be designed to provide control of individual deformation modes (e.g., finite numbers of Zernike modes), with minimal interactions among modes.

This work was done by Randall K. Bartman, Paul K. C. Wang, Linda M. Miller, Thomas W. Kenny, William J. Kaiser, Fred Y. Hadaegh, and Michael L. Agronin of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 79*** *on the TSP Request Card. NPO-19154*

Scene Generation Test Capability

Lasers can test focal plane arrays against realistic mission scenarios.

Engineering Development Center, Arnold Air Force Base, Tennessee

A scene generation test capability (SGTC) has been developed that can test visible and IR sensor subsystems. This capability will enable sensor developers to reduce development risks by testing focal plane arrays (FPAs) and data subsystems against realistic mission scenarios in a space environment. The SGTC can simulate the sensor's mission by projecting complex scenes directly onto the sensor's array in real time. Such scenes will test a sensor's capacity to detect, track, and discriminate targets against realistic backgrounds. The SGTC was implemented in two phases, the transportable direct-write scene generator and the focal plane array test chamber.

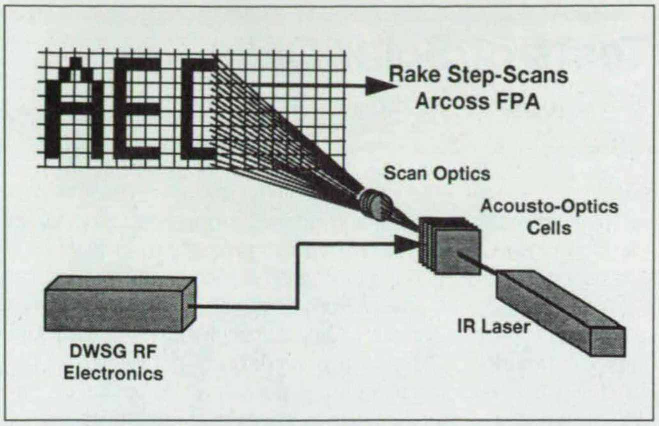
The SGTC uses laser beams to paint scenes directly onto the sensor's FPA much as an electron gun paints pictures directly onto a television screen. Like a movie, a mission scenario is broken down into a sequence of individual scenes or frames. SGTC scenes are created in the visible and infrared at discrete wavelengths and projected onto the FPA in real time. The SGTC design is versatile enough to accept scene data from a variety of sources such as the Strategic Scene Generation Model (SSGM) and SDIO's Phenomenology Data Centers. The scenes projected by the SGTC are virtually unlimited in content.

The key to the success of the SGTC is the direct-write scene generator (DWSG) technique (see figure), which uses acousto-optic devices to position and control the intensity of the laser beam that paints the scene. Scene information is fed into a complex electronic system that controls the acousto-optic devices. The DWSG is synchronized to the FPA integration time to ensure proper registration of each frame or image. The image processing system is capable of controlling this synchronization, as well as creating, editing, and displaying the contents of the scene.

The advantage of an electronically controlled, computer-programmable system is that each pixel is addressed directly during each frame of operation. The ease of storage and playback facilitates comparison testing between various FPAs. The main strengths of the DWSG system are: (1) relatively unlimited scene content (blooming targets, complex backgrounds, plumes, gamma events); (2) compatibility with staring or scanning FPAs; (3) no moving parts in the cryovacuum environment; and (4) lower initial and operating costs.

The system can also simulate the effects of degraded sensor components such as optics, focal planes, and stray light control baffles. Algorithm robustness can be evaluated by the controlled addition of noise to the scenario.

The use of a laser as an external radiation source in conjunction with narrow spectral bandpass filters means that the test



Schematic of the **direct-write scene generator**.

article can be placed in a small cryovacuum dewar rather than a large test chamber. The DWSG hardware can reside outside this dewar as well, so that physical changes do not have to be made with the test chamber at ambient conditions whenever scene content is changed. Time to change scenes and/or mission scenarios is reduced to a matter of hours. Time to reconfigure the test capability from one sensor type to another (starer to scanner or vice-versa) is estimated at two to four weeks. A traceable blackbody reference source, also located outside the chamber, is used to perform blackbody characterizations of the test article, thus providing a critical traceability path from DWSG scenes to real-world phenomena.

The transportable direct-write scene generator (TDWSG) was developed to validate the DWSG concept and meet near-term test needs. A single TDWSG module, using a 1.06-micrometer laser, can paint a scene area as large as 128X128 pixels. There are twelve such modules currently available.

A validation test was conducted using an 80-frame scenario developed using the strategic scene generation model. The scenario consisted of several targets over a mountain-sea background. The first test used an FPA (128 by 128) with 20-micrometer pixels and a cutoff wavelength of 2 micrometers. The scenario was projected at a frame rate of 0.5 kHz.

The second validation test was successfully performed using an FPA (6 by 64) with 100-micrometer pixels and a cutoff wavelength of 25 micrometers. The same scenario was projected at a frame rate of 3 kHz. The 1.06-micrometer laser source successfully addressed both FPAs despite the wide difference in cutoff wavelength (visible vs. LWIR). System stability tests have been performed as well. Single DWSG modules can be grouped together to address a variety of test requirements such as large rectangular or offset test areas.

Development of a more capable yet transportable focal plane array test chamber was completed last year. The scene generation hardware is located outside the chamber (one of three types is available) at ambient conditions. A traceable blackbody reference source is used to perform characterizations of the test article. As with the TDWSG, this establishes a critical traceability path from the scene generated with the DWSG to real-world phenomena. Hardware and software tests have been completed for this program; scene projection demonstrations have been performed at 0.514, 1.06, and 5.4 micrometers, and the system is ready for use. A 10.6-micrometer diagnostic capability also exists.

This work was done by Microcraft Technology, Inc., the aerodynamic ground-test contractor for the **Arnold Engineering Development Center.** *Inquiries concerning rights for the commercial use of this invention should be addressed to Heard Lowery, Arnold Engineering Development Center, Arnold AFB, TN 37389-6400; (615) 454-3709.*

Correcting for Capacitance in Tests of Solar Cells

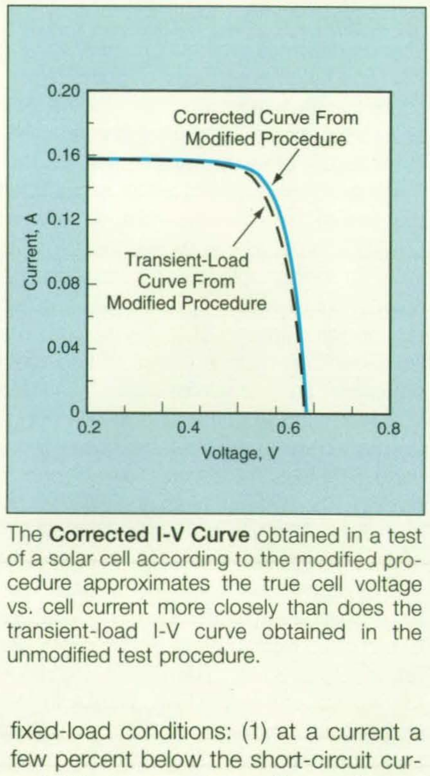
Modifications of the test procedure and software yield corrected *I-V* characteristics.

NASA's Jet Propulsion Laboratory, Pasadena, California

A modified procedure for testing solar photovoltaic cells and modified software for processing the test data provide corrections for the effects of cell capacitance. The modified test procedure and software are needed because (a) some photovoltaic devices (for example, silicon solar cells with a back-surface field region) store minority charge carriers in the cell junction and thus exhibit significant capacitance, (b) capacitance affects current-vs.-voltage (*I-V*) measurements made when a transient load is connected to a cell, and (c) a transient load is used in the unmodified version of the test procedure.

In the modified testing procedure as in the unmodified one, *I* and *V* are measured under various loads when the solar cells are illuminated by a pulsed source of artificial sunlight. The first part of the modified procedure consists of the unmodified procedure, in which *I-V* measurements are taken as the load is swept from short to open circuit during a pulse of artificial sunlight. This procedure yields a complete *I-V* curve, but in the case of high cell capacitance this procedure yields measured values of *V* that are below the true cell voltages for the corresponding measured values of *I*.

In the modified procedure, *I-V* measurements are also taken under four fixed-load conditions: (1) at a current a few percent below the short-circuit current, (2) at a current near the maximum-power point, (3) at half the short-circuit current, and (4) near the open-circuit voltage, where the current is only a few percent of the short-circuit current.



The **Corrected I-V Curve** obtained in a test of a solar cell according to the modified procedure approximates the true cell voltage vs. cell current more closely than does the transient-load I-V curve obtained in the unmodified test procedure.

The modified software uses the fixed-load *I-V* data, which lie on the true *I-V* curve, to produce an interpolated *I-V* curve that closely represents true *I-V* data. This approximation of the true *I-V* curve resembles the transient-load *I-V* curve but is shifted to slightly higher voltage at a given current (see figure).

This work was done by Robert L. Mueller of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 2*** *on the TSP Request Card. NPO-19516*

Laser-Based Metal Surface Decontamination System

A new system reduces secondary wastes and provides more protection for personnel.

Ames Laboratory, Iowa State University, Ames, Iowa

Developed at Ames Laboratory of the US Department of Energy (DOE), a new system uses lasers to remove contaminants from metal surfaces. Unlike other surface cleaning tools, lasers can be used to remove both tenacious surface coatings and portions of the metal substrate without creating copious secondary wastes. With the proper laser parameters, it is possible to simultaneously ablate and efficiently collect materials from a metal surface. This is particularly useful when samples contain hazardous (i.e., radioactive) or valuable materials.

Laser energy can be transmitted over long distances by either mirrors or fiber optics. Thus, exposure of workers and equipment to hazardous materials can be significantly reduced.

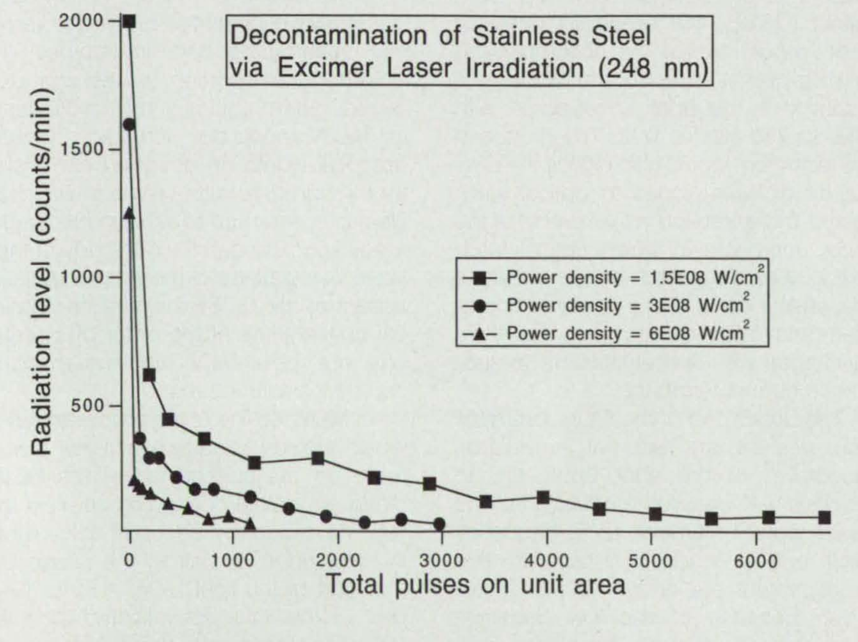
Research in laser surface decontamination at Ames began in 1990 to support the recycling of metal wastes generated during the decommissioning of former DOE facilities. Many millions of tons of stainless steel and high-value metals such as nickel are expected to result from the decommissioning program. Without efficient surface decontamination technologies, these metals could be consigned to landfill burial--a waste of resources and a potential source of pollution.

The technique should find applications in the commercial nuclear industry. Also, it can replace the use of hazardous organic solvents and corrosive acid baths needed for surface cleaning and plating removal, respectively.

During the surface cleaning process, a plasma forms close to the sample's surface. It is possible to control the cleaning process in real time by monitoring a spectral line emitted by the plasma associated with a species of interest.

The technology has been demonstrated on planar and cylindrical surfaces as well as on internal cylindrical surfaces. Cleaning rates vary with the metal treated and the tenacity of the surface coating. For aluminum, an easily ablated material, a radioactive thorium oxide coating deposited during decades of service was removed at rates exceeding two square meters per hour using an excimer laser.

Because the cleaning rate varies sublinearly with the laser's irradiance and linearly with its repetition rate, a high-repetition-rate laser is optimal for surface cleaning. Such a laser was part of a sys-



Decontamination of stainless steel with excimer laser irradiation (248 nm).

tem used to remove fission product contamination from Haynes 25, an extremely hard alloy. Much slower cleaning rates (about 0.1 m^2 per hour) were required than was the case for aluminum. In another application, the surfaces of lead bricks were efficiently decontaminated at high cleaning rates. In each case, an optical fiber delivered energy from the high-repetition-rate laser to the material.

A proprietary system designed to optimize laser removal rates and provide flexible beam-delivery options was developed co-operatively by Ames and Lockheed Martin Idaho Technologies Company (LMIT).

This work was done by Ho-ming Pang and M.C. Edelson for the Dept. of Energy's **Ames Laboratory**. *Russell L. Ferguson at LMIT coinvented the proprietary system.*

Inquiries concerning rights for the commercial use of this invention should be sent to Lidia Clarksean, LMIT, Technology Transfer Office, Idaho National Engineering Laboratory, 2525 Fremont Ave., Idaho Falls, ID 83415 3805; (208) 526-0012.

MQW Optical Feedback Modulators and Phase Shifters

Modulators would consume less drive power and would be compatible with integrated circuits.

NASA's Jet Propulsion Laboratory, Pasadena, California

Multiple-quantum-well (MQW) devices would be used as optical feedback modulators in conjunction with laser diodes, according to a proposal. Laser diodes equipped with the proposed MQW optical feedback modulators may prove useful in a variety of analog and digital optical-communication applications, including fiber-optic signal-distribution networks and high-speed, low-crosstalk interconnections among supercomputers or very-high-speed integrated circuits.

Whereas most of the previous effort to develop MQW modulators focused on exploitation of the electro-absorption aspect of the quantum confined Stark effect (QCSE), the proposed development would exploit the accompanying electro-optical aspect of the QCSE — a variation in the index of refraction with the applied electric field. The proposed development would also exploit the sensitivity of laser diodes to optical feedback. This approach is the reverse of the prior approach, in which optical feedback was regarded as a nuisance because it could cause unstable operation and laser diodes were therefore packaged with optical isolators to suppress optical feedback.

The upper part of the figure illustrates the use of an external modulator, according to the prior approach, to achieve well-behaved modulation of the laser output. Typical radio-frequency and optical insertion losses in this arrangement are about 40 dB. Moreover, because of the low damage-threshold power of the modulator (typically, 10 mW) and optical insertion loss as high as 10 dB in the external modulator, it is often difficult to achieve an acceptably high signal-to-noise ratio at the receiver.

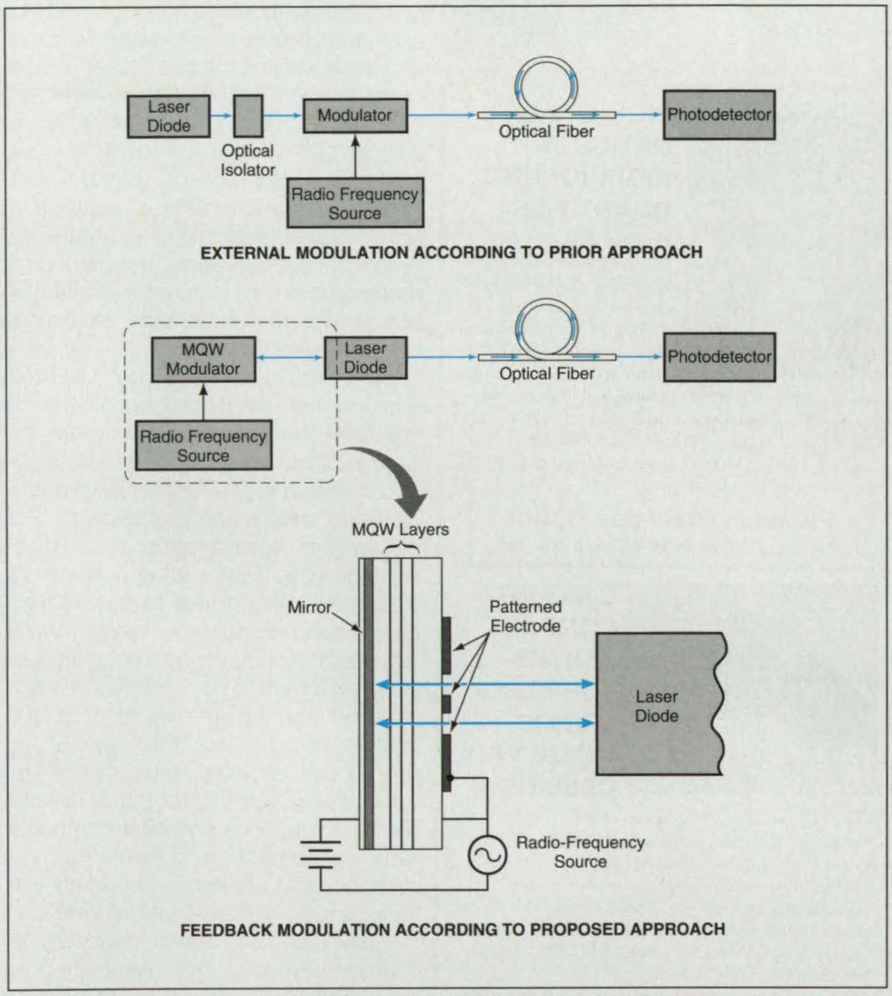
The lower part of the figure illustrates the use of a proposed MQW optical feedback modulator. Because the sizes and capacitances of the proposed MQW optical feedback modulators would be smaller than those of typical external modulators used previously, the proposed modulators would require lower drive voltages. Other expected advantages of the proposed modulators include smaller optical insertion losses and compatibility of MQW structures with control electronic circuits of the monolithic microwave integrated-circuit and very-high-speed integrated-circuit types.

To reduce insertion losses and required radio-frequency drive voltages, an MQW modulator according to the proposal would be designed expressly for the purpose, with a novel MQW and electrode structure to achieve feedback modulation through the back side of the laser. Calculations of the electro-optical aspect of the QCSE indicate that optical phase shifts of the order of π radians are potentially achievable with some MQW structures.

An MQW device of the proposed type would include a patterned metal electrode on the surface facing the laser diode. This electrode would be used to bias the device to reflect part of the light incident upon it, shifting the phase of that part of the light by π radians. The part of the light not reflected by this electrode would enter the device, travel back (leftward in the figure) through the

MQW layers, be reflected from the rear (leftmost in the figure) mirror, pass through the MQW layers again, then leave the device through the electrode gaps and return to the laser. The phase of this part of the light would depend on the voltage applied to the MQW device. Thus, one could vary the phase of light returned to the diode laser in a spatially complex manner, thereby influencing the spatial pattern of the output laser beam. Because changing the spatial pattern of the laser beam would change the efficiency of coupling of the beam into an optical fiber, the part of the beam that entered the fiber would become correspondingly amplitude-modulated.

This work was done by Deborah J. Jackson of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 13*** *on the TSP Request Card. NPO-19310*



The **Proposed Modulation Scheme** would differ from the prior external-modulation scheme in that it would exploit feedback, taking advantage of the electro-optical effect in an MQW device.

Databases for Laser Effects on Aerospace Materials

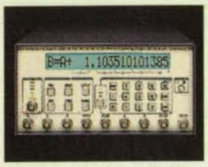
A database resource covers laser effects on many materials.

High Temperature Materials Information Analysis Center, Purdue University, West Lafayette, Indiana

Laser effects data and technical information on aerospace materials are being collected and analyzed from a variety of sources, and will be made available to qualified users. The objective is to bring together analyzed data in the form of a computer searchable database for convenient access by user communities. An analyzed database is offered as a means of providing informational support to

LITERATURE SPOTLIGHT

Free catalogs and literature for *Laser Tech Briefs'* readers. To order, write in the corresponding number on the Reader Information Request Form (page 99).

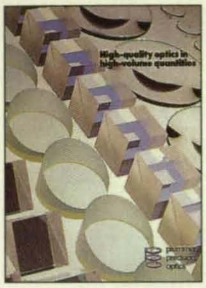


DIGITAL DELAY/PULSE GENERATOR

The DG535 is a four-channel delay generator that can accurately provide four independent delays or two pulses with 5-picosecond resolution. Each output level is independent and can be set from -3 to +4 V. The instrument may be triggered at rates up to 1 MHz (internally or externally) with channel-to-channel jitter less than 50 ps rms. A GPIB (IEEE-488) computer interface is standard. DG535 Delay Generator, US List Price $3500. Tel: 408-744-9040.

Stanford Research Systems

For More Information Write In No. 390



HIGH-QUALITY OPTICS IN HIGH-VOLUME QUANTITIES

Plummer Precision Optics' full-color brochure outlines its total in-house capabilities, from polishing and coating to finished assemblies--everything needed to manufacture high-quality optics ranging from 0.2-12 in. diameter. Plummer delivers quality custom optics in high volumes economically and on time. Statistical Process Control monitors product quality and controls processes, and sophisticated testing equipment insures conformity to MIL-I-45208.

Plummer Precision Optics

For More Information Write In No. 391

1995 BERTAN HIGH-VOLTAGE POWER SUPPLY CATALOG

A newly updated version of Bertan's high-voltage power supply reference and catalog is now available. This guide features detailed specifications on precision DC power supplies with outputs ranging from 100 V to 125 kV. The publication also includes a section covering theory of operation, a glossary of terms, and a handy selection and applications guide. Bertan High Voltage Corp., 121 New South Road, Hicksville, NY 11801; Tel: 800-966-2776; e-mail : info@bertan.com.

Bertan High Voltage Corp.

For More Information Write In No. 392

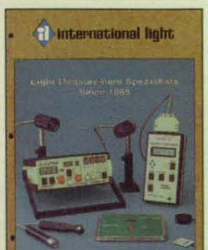
C-MOUNT COMPACT LENSES FOR ELECTRONIC IMAGE PROCESSING

- for 1/2" and 2/3" CCD imaging devices
- ruggedized design for industrial applications
- variable iris, with locking mechanism
- variable focus, with locking mechanism
- optically designed for spectral range 400 nm to 1000 nm

SCHNEIDER CORPORATION OF AMERICA, 400 Crossways Park Drive, Woodbury, NY 11797; Tel: 516-496-8500; Fax: 516-496-8524.

Schneider Corporation of America

For More Information Write In No. 393

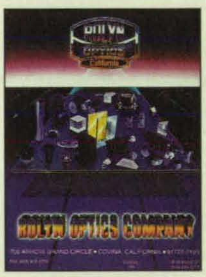


LATEST VERSION LIGHT MEASUREMENT CATALOG

IL offers their latest version full-line catalog describing instrumentation, applications and basic concepts of Radiometry/Photometry. Many new products are introduced, including the IL1800 Lock-in Radiometer, A420 Optical Chopper and various application dedicated detector/filter/input optic configurations. All technical details such as spectral and spatial responses, measurement ranges and descriptions have either been updated, enlarged or expanded in scope.

International Light

For More Information Write In No. 394



FREE CATALOG: OFF-THE-SHELF OPTICS

Free 130-page product catalog from Rolyn, the world's largest supplier of "off-the-shelf" optics. 24-hour delivery of simple or compound lenses, filters, prisms, mirrors, beamsplitters, reticles, objectives, eyepieces plus thousands of other stock items. Rolyn also supplies custom products and coatings in prototype or production quantities.

Rolyn Optics Co.

For More Information Write In No. 395

several types of laser-effects data requirements, from public-access information through restricted levels including classified data.

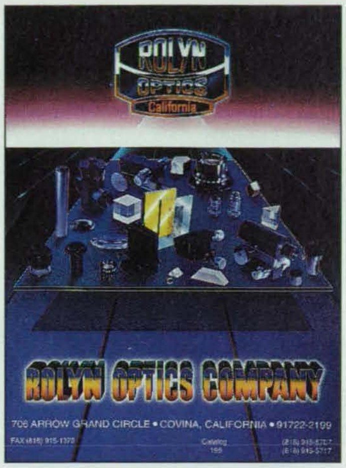
The US Department of Defense High Temperature Materials Information Analysis Center (HTMIAC), which is operated by the Center for Information and Numerical Data Analysis and Synthesis (CINDAS) of Purdue University, is sponsored by the Defense Technical Information Center. HTMIAC's mission is to promote timely dissemination of information and provide unbiased data-analytical and evaluative support on topics within its scope. Laser effects coverage by HTMIAC concerns laser-induced damage, damage threshold, and property degradation following exposure. Definition of damage, test methods, and laser-beam parameters are of course also important. Materials of interest include aerospace structural materials, infrared detector materials, optical system components, insulation, coatings, and filters, etc.

Data and information are collected from government reports and, depending upon the data restriction levels for each project, from public access literature available in the form of journal articles and conference proceedings. For one project currently under way, HTMIAC staff have been visiting government document repositories to assemble a laser-effects database covering various wavelengths on many different materials. Another current topic of interest is laser-induced damage-threshold data that have been published in the open literature for optical system components. The databases will be distributed in diskette form for use on a personal computer. One version will be a public-access diskette, and another a classified version containing all available information.

Laser use is increasing, especially for industrial applications. Accessing an information repository should prove a much less expensive way of satisfying data requirements compared to regenerating new test data.

The point of contact for this activity is Dr. R.H. Bogaard of the High Temperature Materials Information Analysis Center of the **Defense Technical Information Center.** *Dr. Bogaard may be reached at HTMIAC/CINDAS, Purdue University, 2595 Yeager Rd., West Lafayette, IN 47906-1398; (317) 494-9393; FAX (317) 496-1175. For further information* ***write in 15*** *on the TSP Request Card.*

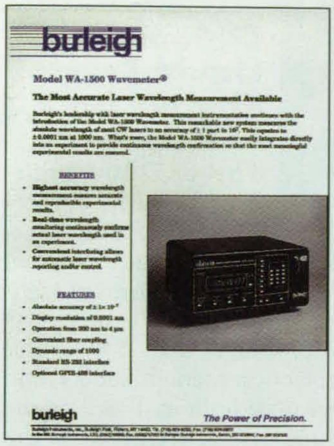
NEW LITERATURE



Catalog Optics for Industry

Catalog 195 from Rolyn Optics Co., Covina, CA, has 128 pages of reference data, product offerings, and specifications for the house's lines of lenses, mounts, accessories, and other components. Included are simple and compound lenses, photolenses, enlarging lenses, prisms, flat and concave mirrors, flats and glass, neutral density and other filters, beamsplitters, reticles and gratings, microscopes, mounts, and HeNe lasers.

For More Information Write In No. 815



High-Accuracy CW Wavelength Measurement

Burleigh Instruments, Fishers, NY, calls its Model WA-1500 Wavemeter™ the most accurate laser wavelength-measurement instrument available. The specification sheet indicates absolute wavelength measurement accuracy for most continuous-wave lasers to ±1 part in 107, or ±0.0001 nm at 1000 nm. Real-time monitoring continuously confirms actual wavelength as an experiment progresses. Effective range is from 200-4000 nm.

For More Information Write In No. 818

Narrow-Linewidth Ti: Sapphire Laser

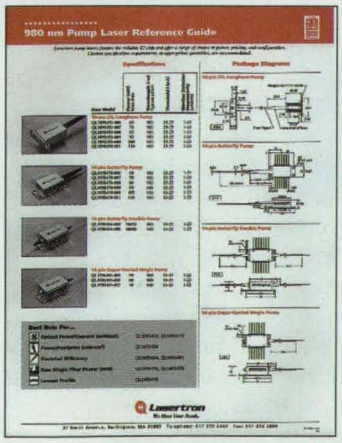
A specification sheet for the SenTinel, the newest addition to its solid-state laser line from MPB Technologies, Dorval, PQ, Canada, says the tunable flashlamp-pumped Ti:sapphire laser has the narrowest linewidth of its kind available. It is grating-tunable from 690-980 nm with a single set of mirrors, with a linewidth throughout this range of 0.005 nm. Additional line narrowing to 0.0005 nm can be achieved with an optional intracavity etalon.

For More Information Write In No. 816

Analog Convection Transducer

The HPS Division of MKS Instruments Inc., Boulder, CO, releases a single-sheet full-color brochure on its SensaVac® Series 907 Analog Convection Transducer, a convection-enhanced Pirani sensor integrated with an electronic control circuit. Capable of measuring vacuum pressure from 10^{-3} to 1000 Torr, the 907 can be used as a system control element, relay, gauge, alarm, and remote sensor. The brochure describes the 907's operating principle, specifications, and pricing.

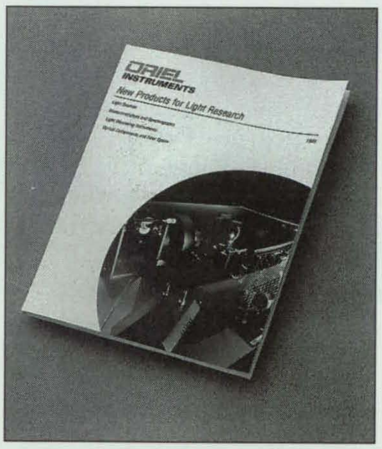
For More Information Write In No. 819



980-nm Pump Laser Reference

Lasertron, Burlington, MA, makes available a specification sheet called the "980-nm Pump Laser Reference Guide." The pumps are used to energize erbium-doped fiber amplifiers for long-distance fiber optic telecommunications. The sheet describes the company's 14 980-nm pump products, offered in four basic packages: longhorn, butterfly, double pump and "super-cooled" single pump.

For More Information Write In No. 817



Making, Moving, and Measuring Light

The "New Products for Light Research" catalog from Oriel, Stratford, CT, features the company's latest instruments for making, moving, and measuring light, including pulsed sources, nitrogen lasers, calibrated irradiance sources, imaging monochromators and spectrographs. Also included are a full line of UV-IR detectors, CCDs, ICCs, and fiber optics.

For More Information Write In No. 820

NEW PRODUCTS

C-Mount Liquid Crystal Shutter for CCD Systems

The CC2200 high-speed liquid crystal shutter from Displaytech Inc., Boulder, CO, meets the C-mount-to-C-mount requirements of high-performance charge-coupled-device (CCD) camera systems. It enables exposure times shorter than 200 µs and frame rates greater than 1 kHz. Contrast ratio is 1000:1, and IR and/or UV blocking filters can be built in. Based on the company's ferroelectric liquid crystal technology, the CC2200 can provide exposure control, reduce blur and smearing, and replace mechanical shutters, strobe, or flash-lamp systems.

For More Information Write In No. 801

Gradient Index Capability for Software

Focus Software Inc., Tucson, AZ, announces that LightPath Technologies' LPTPBD lead silicate glass, an axial gradient index (AGRIN) optical material, is to be included in the materials database of XE and EE editions of Focus's ZEMAX optical design program. Because this material's dispersion also varies along the optical axis, the data files contain coefficients describing the variation of Buchdahl coefficients throughout the material, enabling the ZEMAX program to compute the index at any wavelength. Focus's software models lenses, mirrors, tilted and decentered systems, holograms, diffractive optics, and more.

For More Information Write In No. 804

Diode-Pumped Nd:YAG for FT-Raman Spectroscopy

Spectra-Physics Lasers, Mountain View, CA, calls its Model T10-106c an advanced diode-pumped CW laser optimized for high-performance FT-Raman spectroscopy. The Nd:YAG head is pumped by a 10-W diode bar coupled into a bundle of multimode optical fibers. Pump source is field-replaceable without realignment, the company says. Output power is 2.5 W. All diode-pumped products carry a 12-mo. 5000-hr. warranty.

For More Information Write In No. 802

Laser Diode Control Instrumentation

Three new product lines from Newport Corp., Irvine, CA, include temperature controllers, laser diode drivers, and temperature-controlled mounts. The Model 300 series thermoelectric temperature controllers provide control of ±0.005 °C over a range of -50-+150 °C. The Model 500 series drivers span power levels of -50 mA to 6 A. The series 700 mounts have two 12.5-W TE coolers to control diodes with outputs up to 3 W. The Model 740 telecom mounts allow easy mounting of diodes with dual in-line and butterfly packaging.

For More Information Write In No. 805

TE Coolers for Thermal Viewer Systems

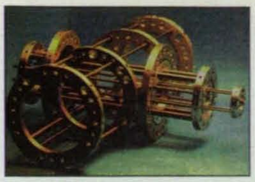
Marlow Industries, Dallas, TX, makes available a broad line of thermoelectric coolers for thermal viewer systems. They provide temperature stabilization down to 175 K in cooled and uncooled FLIR systems. Marlow says the coolers provide no vibration in the focal plane, high mean time between failures, and low life-cycle costs.

For More Information Write In No. 803

Pulse Generators for Noisy Environments

The isolated outputs of the models PG-9310, PG-9410, and PG-9510, making up the new line of power generators from Quantum Composers Inc., Bozeman, MT, were designed specifically for electrically noisy environments. Functions include precise control of pulsewidths and recall of up to 12 saved configurations. All channels have independently programmable pulsewidth, delay, and output polarity. System operating modes include continuous, single-shot, external trigger/gate, and other special control modes.

For More Information Write In No. 806



Optical Construction Plates

AF Optical Co., Trabuco Canyon, CA, offers optical construction plates for component linking and mounting. The system permits the user to detach his setup and use it as a standalone unit. Plates feature built-in post-mount capability and precise three-point mounting and adjustment. Tilts and shifts are possible. Researchers can create setups in the Z direction to expand table capacity, and R&D setups can be converted to portable show-ready systems.

For More Information Write In No. 807

High-G Color Electronic Camera

Eastman Kodak's new EktaPro RO (record-only) image capture device is designed for documenting tests conducted in severe environments, such as crash-sleds. The company says it can withstand up to 100 Gs at 10 ms and up to 50 Gs at 100 ms in any axis. The camera's 16-x-16-µm pixel size suits it for computer image analysis applications. It can record 500 512-x-384-pixel images at up to 100 fps, upgradable to 2000 images next year, Kodak says. Images can be transferred to a PC with a PCMCIA hard drive.

For More Information Write In No. 811

Visible Laser Sensors for Distance Measuring

The visible red laser sensors from Aromat Corp., New Providence, NJ, join the company's broad line of IR devices for measuring and profiling distances. Both are triangulation systems, and thus are less costly than interferometric systems by a factor of 10. Available as the LM100 and LM200 series, the sensors offer measurable ranges from 30-400 mm, small spot size (0.07 x 0.03 mm), and ease of target positioning because of the visible beam.

For More Information Write In No. 808

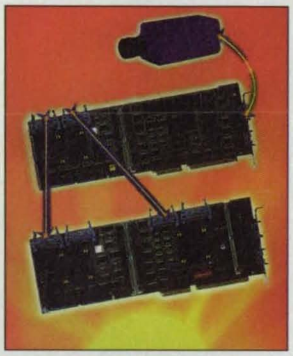


Image Processing with 1000s of MFLOPs

The SPIRIT-Image PC image processing system from Sonitech, Wellesley, MA, is designed for both digital signal processing (DSP) and non-DSP programmers whose tasks need 100s to 1000s of MFLOPs of computation. Standard functions and several example software routines are included for immediate out-of-the-box setup and processing.

For More Information Write In No. 812

Frequency-Doubled Nd:YAG for Industrial Use

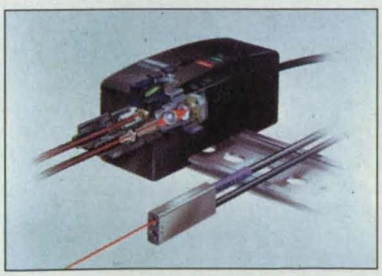
Lee Laser, Orlando, FL, introduces the Model 818TQ/40G, a high-power frequency-doubled Nd:YAG laser for industrial micromachining. Rated at 25 W average at a pulse rate of 10 kHz, the laser is intended for applications where the 530-nm wavelength makes possible greater power absorption or smaller beam focus diameter. Lee's wavelength transfer module enables rapid change between the fundamental 1064-nm wavelength and the 530-nm harmonic.

For More Information Write In No. 809

Laser Eye Protection Filters

Glendale Protective Technologies, Lakeland, FL, has added six absorptive polycarbonate-base eye protection filters to its Laser-Gard™, Laser-Med™ and Laser-Line™ series. The new hard-coated filters are Ti:sapphire, Excimer/CO_2, Laser-Med Argon, Diode I, single-lens Argon/NDGA, and Argon/Krypton. They come in a variety of frame styles.

For More Information Write In No. 813



Photoelectric Sensor with Laser Light Source

Keyence Corp. of America, Woodcliff Lake, NJ, calls its Model FS-L the first fiber optic photoelectric sensor to use a laser light source. The small FS-L amplifier (2.5 in. long x 1.6 in. high x 1.1 in. wide) couples a visible-spot semiconductor laser to a specially designed optical system to produce a parallel beam that can detect a 10-mm object at a distance of 10 m. Response time is 0.25 ms.

For More Information Write In No. 810

Compact Nd:YAG with Wavelength Options

Big Sky Laser, Bozeman, MT, calls its new Model CFR 200/MINICE the smallest, lightest Nd:YAG available. According to the manufacturer, the rugged, environmentally sealed system, designed for maximum flexibility, versatility, and simplicity, is more than 70% smaller than other commercial systems. The laser delivers 200 mJ of Q-switched 1.06-µm energy at up to 30 Hz. Other wavelengths available are 532 nm, 355 nm, 266 nm, and 1.57 µm.

For More Information Write In No. 814


From prototype to production...
UV to FAR IR, Standard, Custom & OEM Optics & Coating Production
• Quality Customer Service & Support
• Custom, Standard, OEM Laser and Imaging Optics
• Complete In-house Capabilities for Design & Production
• UV-FIR State-of-the Art Coating Designs - Standard & High Power
Call our knowledgeable sales team at 303-651-2211
for custom solutions to your technical problems.
RMI
ROCKY MOUNTAIN INSTRUMENT
1501 South Sunset Street
Longmont, CO 80501
Fax (303) 651-2648
Europe 0421-2208-147 • Fax 0421-2208-157
Japan Opto Science 03-3356-1064 • Fax 03-3356-3466
Korea Woo Kyung E-O 345-494-6855 • Fax 345-494-6859

Computer Programs

COSMIC: Transferring NASA Software

COSMIC, NASA'S Computer Software Management and Information Center, distributes software developed with NASA funding to industry, other government agencies and academia.

COSMIC's inventory is updated regularly; new programs are reported in *Tech Briefs*. For additional information on any of the programs described here, write in the appropriate TSP number.

If you don't find a program in this issue that meets your needs, call COSMIC directly for a free review of programs in your area of interest. You can also purchase the annual *COSMIC Software Catalog*, containing descriptions and ordering information for available software.

COSMIC is part of NASA's Technology Transfer Network.

COSMIC® —
Timothy L. Peacock, Director
Phone (706) 542-3265;
FAX (706) 542-4807
The University of Georgia,
382 East Broad Street,
Athens, Georgia 30602

Mathematics and Information Sciences

C-Language Integrated Production System, Version 6.0

CLIPS facilitates the development and delivery of expert-system software.

The C Language Integrated Production System (CLIPS) computer program provides a complete programming environment for developing expert system software — programs that are specifically intended to model human expertise or other knowledge. CLIPS is designed to enable research on, and the development and delivery of, artificial intelligence on conventional computers.

CLIPS 6.0 provides a cohesive software tool for handling a wide variety of knowledge with support for three different programming paradigms: rule-based, object-oriented, and procedural. Rule-based programming enables the representation of knowledge as heuristics — essentially, rules of thumb that specify a set of actions to be performed in a given situation. Object-oriented programming enables the modeling of complex systems comprised of modular components (which can be easily reused to model other systems or create new components). The procedural-programming capabilities provided by CLIPS 6.0 enable the representation of knowledge in ways similar to those of such languages as C, Pascal, Ada, and LISP. CLIPS 6.0 makes it possible to develop expert system software by use of rule-based programming only, object-oriented programming only, procedural programming only, or combinations of these three types of programming.

CLIPS provides extensive features to support the rule-based programming paradigm, including seven conflict-resolution strategies, dynamic rule priorities, and truth maintenance. CLIPS 6.0 supports more complex nesting of conditional elements in the "if" portion of a rule ("and", "or", and "not" conditional elements can be placed within a "not" conditional element). In addition, there is no longer a limitation on the number of multifield slots that a deftemplate can contain.

The CLIPS Object-Oriented Language (COOL) provides capabilities for object-oriented programming. Features supported by COOL include classes with multiple inheritance, abstraction, encapsulation, polymorphism, dynamic binding, and message passing. CLIPS 6.0 supports tight integration of the rule-based programming features of CLIPS with COOL (that is, a rule can pattern match on objects created by COOL).

CLIPS 6.0 provides the capability to define functions, overloaded functions, and global variables interactively. In addition, CLIPS can be embedded within procedural code, called as a subroutine, and integrated with such languages as C, FORTRAN, and Ada. CLIPS can be easily extended by use of several well-defined protocols. CLIPS provides several options for delivery of programs, including the ability to generate stand-alone executables or to load programs from text or binary files.

CLIPS 6.0 provides support for the modular development and execution of knowledge bases with the "defmodule" construct. CLIPS modules enable the grouping together of a set of constructs, such that explicit control can be maintained by restricting access to the constructs by other modules. This type of control is similar to global and local scoping used in such languages as C or Ada. By restricting access to deftemplate and defclass constructs, modules can function as blackboards, permitting only certain facts and instances to be seen by other modules. Modules are also used by rules to provide control over execution.

The CRSV (cross-reference, style, and verification) utility software included in previous versions of CLIPS is no longer included. The capabilities formerly provided by CRSV are now available directly within CLIPS 6.0 to aid in the development, debugging, and verification of large rule bases.

COSMIC offers four distribution versions of CLIPS 6.0: UNIX (MSC-22433), VMS (MSC-22434), Macintosh (MSC-22429), and IBM PC (MSC-22430). Executable files, source code, utility software, documentation, and examples are included on the program media. All distribution versions include identical source code for the command-line version of CLIPS 6.0. This source code should be compilable on any computer equipped with an ANSI C compiler. Each distribution version of CLIPS 6.0, except that for the Macintosh computer, includes an executable for the command-line version. For the UNIX version of CLIPS 6.0, the command-line interface has been successfully compiled on a Sun4 computer running SunOS, a DECstation computer running DEC RISC ULTRIX, an SGI Indigo Elan computer running IRIX, a DEC Alpha AXP computer running OSF/l, and an IBM RS/6000 computer running AIX. Command-line interface executables are included for Sun4 computers running SunOS 4.1.1 or later and for the DECstation computer running DEC RISC ULTRIX. The makefiles may have to be modified slightly to be used on other computers running UNIX.

The UNIX, Macintosh, and IBM PC versions of CLIPS 6.0 each include a platform-specific interface. Source code, a makefile, and an executable for the Windows 3.1 interface version of CLIPS 6.0 are provided only on the IBM PC distribution diskettes. Source code, a makefile, and an executable for the Macintosh interface version of CLIPS 6.0 are provided only on the Macintosh distribution

diskettes. Likewise, for the UNIX version of CLIPS 6.0, only source code and a makefile for an X-Windows interface are provided. The X-Windows interface requires MIT's X Window System, Version 11, Release 4 (XIIR4) or later, the Athena Widget Set, and the Xmu library. The source code for the Athena Widget Set is provided on the distribution medium. The X-Windows interface has been successfully compiled on a Sun4 computer running SunOS 4.1.2 with the MIT distribution of XIIR4 (not OpenWindows), an SGI Indigo Elan computer running IRIX 4.0.5, and a DEC Alpha AXP computer running OSF/I 1.2.

The VAX version of CLIPS 6.0 comes only with the generic command line interface. ASCII makefiles for the command-line version of CLIPS are provided on all the distribution media for UNIX, VMS, Macintosh, and DOS.

Four executables are provided with the IBM PC version: a windowed interface executable for Windows 3.1 built by use of Borland C++ v3.1, an editor for use with the windowed interface, a command-line version of CLIPS for Windows 3.1, and a 386 command-line executable for DOS built by use of Zortech C++ v3.1. All four executables are capable of utilizing extended memory and require an 80386 or better central processing unit (CPU). Users who need executables on 8086/8088 or 80286 CPUs must recompile the CLIPS source code themselves. Users who wish to recompile the DOS executables by use of Borland C++ or Microsoft C must use a DOS extender program to produce an executable capable of using extended memory.

The version of CLIPS 6.0 for IBM PC-compatible computers requires DOS v3.3 or later and/or Windows 3.1 or later. It is distributed on a set of three 1.4-MB, 3.5-in. (8.89-cm) diskettes. A hard disk is necessary. The Macintosh version is distributed in compressed form on two 3.5-in. (8.89-cm), 1.4-MB Macintosh-format diskettes, and requires System 6.0.5 or higher, plus 1 MB of random-access memory. The version for DEC VAX/VMS is available in VAX BACKUP format on a 1,600-bit/in. (630-bit/cm), 9-track magnetic tape (standard distribution medium) or a TK50 tape cartridge. The UNIX version is distributed in UNIX tar format on a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24). For the UNIX version, alternate distribution media and formats are available upon request.

The CLIPS 6.0 documentation includes a user's guide and a three-volume reference manual that consists of basic and advanced programming guides and an interfaces guide. An electronic version of the documentation is provided on the distribution medium for each version: in Microsoft Word format for the Macintosh and PC versions of CLIPS, and in both PostScript format and Microsoft Word for Macintosh format for the UNIX and DEC VAX versions of CLIPS. CLIPS was developed in 1986 and version 6.0 was released in 1993.

This program was written by Gary Riley, Brian Donnell, Huyen-Anh Bebe Ly, and Chris Ortiz of **Johnson Space Center.**

For further information on MSC-22429, ***write in 226*** *on the TSP Request Card.*

For further information on MSC-22430, ***write in 227*** *on the TSP Request Card.*

For further information on MSC-22433, ***write in 228*** *on the TSP Request Card.*

For further information on MSC-22434, ***write in 229*** *on the TSP Request Card.*

MSC-22429/MSC-22430/MSC-22433/MSC-22434.

Move to the Plus Side of Math –

NEW!

IMSL® Math Module for C++ . . .

positively the easiest way to develop technical applications!

Get your math from the math experts.

Now the object-oriented development tools you need are available from the name you have relied on for nearly 25 years for numerical analysis and technical application development. The IMSL Math Module for C++ is the first release from Visual Numerics' new family of object-oriented development tools, Visual Numerics' Object*Suite*™.

The **IMSL Math Module for C++** uses the power and flexibility inherent in the C++ language to greatly reduce coding requirements. The combination of powerful algorithms and ease-of-use makes the **IMSL Math Module for C++** ideally suited for object-oriented programmers building business, scientific, and research applications. The Module's object-oriented interface provides a natural algebraic approach to mathematical programming.

- ➤ Includes classes in a variety of precisions for
  - complex arithmetic
  - vectors
  - matrices (symmetric, positive definite, general)
  - matrix decomposition (QR, LU, Cholesky, SVD, Diagonal Pivoting)
  - interpolation and approximation
  - pseudorandom number generation (uniform, normal, Poisson, gamma, beta, exponential)
- ➤ Conforms to established conventions of C++ programming.
- ➤ Built upon efficient algorithms.
- ➤ Includes comprehensive online documentation.

Here's why you should build your applications with the IMSL Math Module for C++:

You will:

- ➤ dramatically decrease your development time.
- ➤ save thousand of dollars in design, testing and maintenance.
- ➤ get comprehensive online documentation.
- ➤ save- no fees for run-time licenses.
- ➤ develop object-oriented cross-platform solutions.

Supported systems:

- Intel-based PCs running Windows with Win32s or Windows NT
- Sun Microsystems and Hewlett-Packard workstations
- Coming soon for Windows 95

See why over 250,000 developers worldwide use IMSL for mission-critical applications.

Get your math from the math experts. Call today!

1-800-364-8880

Visual Numerics®

phone (713) 954-6785 fax (713) 781-9260
e-mail: marketing@houston.vni.com
http://www.vni.com
London +44 (0) 1753-790600 • **Paris** +33-1-46-93-94-20
Stuttgart +49-711-13287-0 • **Taiwan** 886 (0) 2-727-2255 • **Tokyo** +81-3-5689-7550

IMSL Fortran and C/C++ Application Development Tools

PURIFY'd.

For More Information Write In No. 600

AD95124

Pairwise-Comparison Software

This program collects similarity data for psychometric scaling and cognitive research.

PWC (which stands for "pairwise comparison") is a computer program that collects data for psychometric scaling techniques now used in cognitive research. The cognitive tasks and processes of human operators of automated systems are considerations that now figure prominently in the process of defining requirements for such systems. Recent developments in cognitive research have emphasized the potential utility of such psychometric scaling techniques as multidimensional scaling for representing human knowledge and cognitive processing structures. Such techniques involve collecting measurements of stimulus-relatedness from human observers. When data are analyzed according to these scaling approaches, an *n*-dimensional representation of the stimuli is produced. This representation is said to describe the subject's cognitive or perceptual view of the stimuli.

PWC applies the technique of pairwise comparisons, which is one of the many techniques commonly used to acquire the data necessary for these types of analyses. PWC administers the task, collects the data from the test subject, and formats the data for analysis. It thereby addresses many of the limitations of the traditional "pen-and-paper" methods. By automating the data-collection process, PWC prevents subjects from going back to check previous responses, eliminates the possibility of erroneous transfer of data, and eases the burden of administering and taking the test in which the data are acquired. By use of randomization, PWC ensures that subjects see the stimuli pairs in random order, and that each subject sees pairs in a different random order.

PWC is written in Turbo Pascal v6.0 for IBM PC-compatible computers running MS-DOS. The program has also been successfully compiled with Turbo Pascal v7.0. A sample executable code is provided. PWC requires 30K of random-access memory for execution. The standard medium for distribution of this program is a 5.25-in. (13.335-cm), 360K MS-DOS-format diskette. Two electronic versions of the documentation are included on the diskette: one in ASCII format and one in MS Word for Windows format. PWC was developed in 1993.

This program was written by Wendell R. Ricks of **Langley Research Center.** *For further information,* ***write in 160*** *on the TSP Request Card. LAR-15143*

Software for Computing Reliability of Other Software

Nonspecialists will likely prefer this program to others developed for the same purpose.

The Computer Aided Software Reliability Estimation (CASRE) computer program is a software tool developed for use in measuring the reliability of other software. CASRE is easier for nonspecialists in reliability to use than are many other currently available programs developed for the same purpose.

During the past 20 years, mathematical models of the reliability of software have been developed; these models can be used to predict the rates of failure of software systems. These models can be useful management tools during testing periods, enabling developers to (1) determine when the required

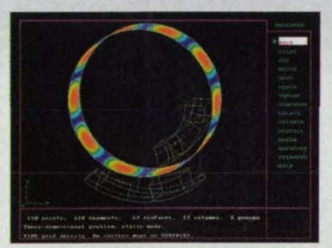
These won't save you time or money...

$$\nabla \times H = J + \epsilon \frac{\partial E}{\partial t} \qquad \nabla \times E = -\mu \frac{\partial H}{\partial t} \qquad \nabla \cdot E = \frac{\rho}{\epsilon} \qquad \nabla \cdot H = 0$$

THESE WILL.

A CAE package that provides immediate productivity and saves prototyping dollars is very hard to find. With our line of fully integrated BEM electromagnetic simulation software, we can help.

Each of our packages is designed around three basic principles: advanced technology, productivity and exceptional customer service.



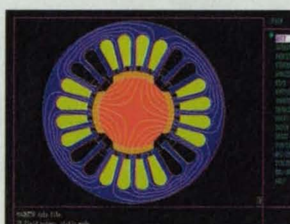
B-Field Bands: Periodic condition on a magnetic clutch for arbitrary rotor position.

Advanced Technology

"I have analyzed literally hundreds of linear and non-linear electromechanical devices with IES software. It has become an invaluable tool to me, as it's so much easier to work with than FEM software. Unlike FEM, BEM software does not necessitate any regriding of the problem when one medium is being rotated or translated with respect to another, which results in a significant time saving."

Dr. Kent Davey
American Maglev

Progressive features like our automatic/adaptive boundary element refinement, relative error detection, 3D symmetry conditions and a consistent graphic interface give you the most advanced programs available anywhere.



Torque vs. position curves for optimal motor design are readily calculated.

Productivity

"IES BEM programs have consistently outperformed the seven FEM packages I have evaluated in the past few years. The operator interface of IES programs allows for immediate productivity, where there is a significant learning curve involved in all FEM packages."

Nicholas F. Campagna
Consultant

We have set up sample problems for you to work through along with databases of solved problems comparable to conventional industry-specific needs. Shorten the steps to your solution with IGES or DXF geometry translators and parametric definitions.

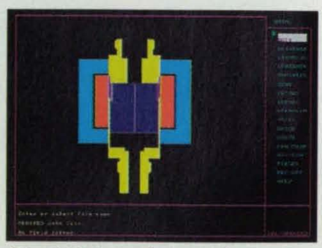
Customer Service

"IES has consistently impressed us with their speed of response and strong commitment to work with us on unique problems."

Jim Aydelotte
Dynacast Magnetics

On-line help, full technical support and two complete program enhancements each year keep you on the cutting edge of CAE design and analysis.

Load a single diskette or tape onto your PC or workstation. Within one day you will begin working on your own problems. In just a week, even the most sophisticated 3D design solutions are yours. We give you our word. And so have our customers.



Use BEM to solve non-linear eddy current problems.

Call today for your 30-day no-charge software evaluation.

INTEGRATED
ENGINEERING SOFTWARE

TEL: (204) 632-5636 FAX: (204) 633-7780
e-mail: info@integrated.mb.ca

reliabilities of software systems have been achieved, (2) estimate the times and efforts necessary to achieve required levels of reliability, and (3) quantitatively assess the effects of shortages of resources during testing periods.

CASRE incorporates the mathematical modeling capabilities of the public-domain Statistical Modeling and Estimation of Reliability Functions for Software (SMERFS) computer program and runs in a Windows software environment. CASRE provides a menu-driven command interface; the enabling and disabling of menu options guides the user through the (1) selection of a set of failure data, (2) execution of a mathematical model, and (3) analysis of the results from the model.

Input to the models is simultaneously displayed as text and in a high-resolution form that can be controlled to enable the user to view the data in several different ways; for example, times between successive failures or cumulative numbers of failures. Predictions made by a model and statistical evaluations of the applicability of a model can be superimposed on a plot of data used as input to the model.

CASRE also incorporates earlier findings that the accuracy of prediction can be increased by combining the results of several models in a linear fashion. Users can define their own combinations of models, store them as part of the software configuration, and execute them in the same way as that of any other model.

This program would be particularly useful to software-development organizations searching for ways to manage their development resources more effectively. Inasmuch as CASRE was developed with the nonspecialist in mind, it should gain wider acceptance than do those software tools that require detailed knowledge of the models.

CASRE is written in C language for IBM PC-series and compatible computers running MS-D0S v5.0 or higher. This program requires 1MB of disk space for installation and up to 64KB of disk space for every failure-history file. The minimum required hardware and software required for running CASRE is the following: an 80386 processor with an 80387 coprocessor; Windows 3.1; 4MB of random-access memory (RAM); a mouse, trackball, or equivalent pointing device; a 16-in. (41-cm) or larger VGA monitor; and a video circuit card supported by Windows 3.1. Although CASRE can be executed on this minimum required hardware and software, the minimum combination of hardware and software recommended for execution of CASRE is the following: a 66-MHz 80486 DX/2 hardware system; Windows 3.1; at least 8MB of RAM; a mouse, trackball, or equivalent pointing device; a 19-in. (48-cm) VGA monitor; and a laser printer with a resolution of at least 300 dots per inch (12 dots per millimeter). CASRE may not function correctly on hardware based on the local bus architecture. The standard medium for distribution of CASRE is a 3.5-in. (8.89-cm), 1.44MB MS-DOS-format diskette. CASRE was developed in 1993 and is a copyrighted work with all copyright vested in NASA.

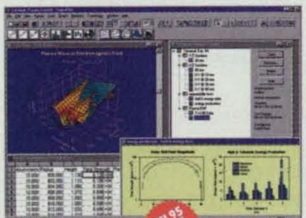
This program was written by Allen Nikora, Thomas M. Antczak, and Michael Lyu of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 3*** *on the TSP Request Card. NPO-19307*

Count it! Measure it! Stat it! Fit it! Plot it! We've got it!

WINDOWS 95 COMPATIBLE 32 BIT VERSION

Introducing the latest generation of the Jandel software family

Jandel Scientific Software announces a new generation of our product family – including many fast new 32-bit versions for Windows 95 and NT. Now, with OLE 2, you can use a Excel spreadsheet inside SigmaPlot and SigmaStat – or you can directly edit an embedded graph within Microsoft Word. Jandel Scientific – the leading family of scientific and engineering software since 1982.



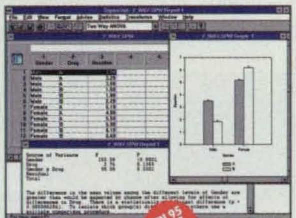
SigmaPlot

WIN 95 32-BIT VERSION

FLEXIBLE SCIENTIFIC GRAPHING

From nonlinear regressions to multiple axes per graph, more than 75,000 researchers depend on award-winning SigmaPlot's flexibility and power to analyze and graph their technical data the way they need to.

Mac 625 Win 626



SigmaStat

WIN 95 32-BIT VERSION

ADVISORY STATISTICAL SOFTWARE

Advises on the test to use, checks for violations in underlying assumptions, runs the test, and explains the results. Handles messy data. Like having a professional statistical consultant at your fingertips.

Write In No. 627

SigmaScan

NEW VERSIONS

IMAGE MEASUREMENT

SigmaScan Pro

IMAGE ANALYSIS

Easy, accurate and low-cost. SigmaScan for manual image measurements or SigmaScan Pro for automated measurements, counting, and image analysis.

Write In No. 628

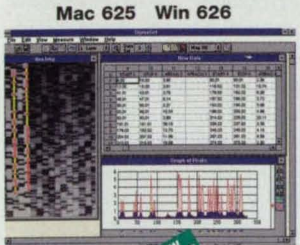
SigmaSuite

NEW VERSION

INTEGRATED GRAPHING, STATISTICS & IMAGE MEASUREMENT

The power of SigmaPlot, SigmaStat, and SigmaScan at a Suite price! Measure images, run statistics, and create graphs using SigmaLink for seamless data sharing in all three products.

Write In No. 629



SigmaGel

NEW PRODUCT

GEL ANALYSIS SOFTWARE

Gel analysis – spot, lane, molecular weight, and DNA – on your lab or office PC. Works with inexpensive hand or desktop TWAIN-compatible scanners and imaging devices. Quality and speed previously available only in higher priced systems.

Write In No. 630

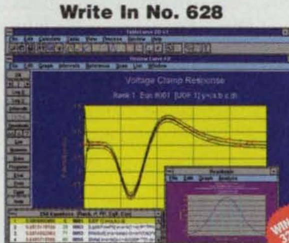
PeakFit

WIN 95 32-BIT VERSION

AUTOMATED NONLINEAR PEAK SEPARATION AND ANALYSIS

Automatically smoothes, finds, separates, fits, and analyzes Spectroscopic, Chromatographic, and Electrophoretic peaks. 91 built-in equations. Up to 15 UDFs. Advanced baseline subtraction and much more...

Write In No. 631



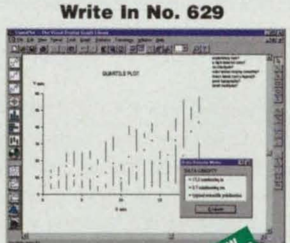
TableCurve 2D & 3D

WIN 95 32-BIT VERSION

AUTOMATED EQUATION DISCOVERY AND FITTING FOR EMPIRICAL DATA

2D fits 3,456 equations (XY)
3D fits 453,697,365 (XYZ)
They statistically rank each fit and allow the user to pick the best one, including up to 15 UDFs. All in seconds!

Write In No. 632



Visual Display Graph Library

NEW PRODUCT

Dr. Edward Tufte designed The Visual Display Graph Library using the unique flexibility of new SigmaPlot. This new graph library includes: *The Visual Display of Quantitative Information* book, data density meter, style guidelines, fonts, and templates.

Write In No. 633

TO GET IT CALL 1-800-4-JANDEL (1-800-452-6335)

FOR MORE INFORMATION PLEASE CALL, FAX OR E-MAIL:
Jandel Scientific: 2591 Kerner Blvd., San Rafael, CA 94901
415-453-6700 Fax 415-453-7769 **Internet:** sales@jandel.com
In Europe: Jandel Scientific, Schimmelbuschstrasse 25, 40699 Erkrath, Germany 02104/9540 02104/95410 (FAX).

International Dealers: Australia 2 958 2688, Brazil 11 453 5588, Canada 519 767 1061, Chile 56 2 635 2422, Hong Kong 852 739 2001, India 40 31 3368, Israel 972 349 0823, Japan 3 3590 2311, 3 5689 8000, Korea 822 886 3983, Kuwait 965 242 1851, Malaysia 603 777 2597, Mexico 525 513 0399, South Africa, 12 660 2884, Taiwan 2 788 6777, 2 705 1590

Jandel
SCIENTIFIC SOFTWARE

Ceramic Replaces Metal in High Performance Optomechanical Structures

Ceramic components feature dimensional stability, low cost, and ease of fabrication.

Langley Research Center, Hampton, Virginia

Recently developed ceramic materials and fabrication techniques have been integrated by Langley Research Center workers to produce superior optomechanical structures for spacecraft and aircraft instrumentation. The basic features of these novel supports, such as dimensional stability, low cost, and ease of fabrication, also make them ideal for many commercial optical systems as well.

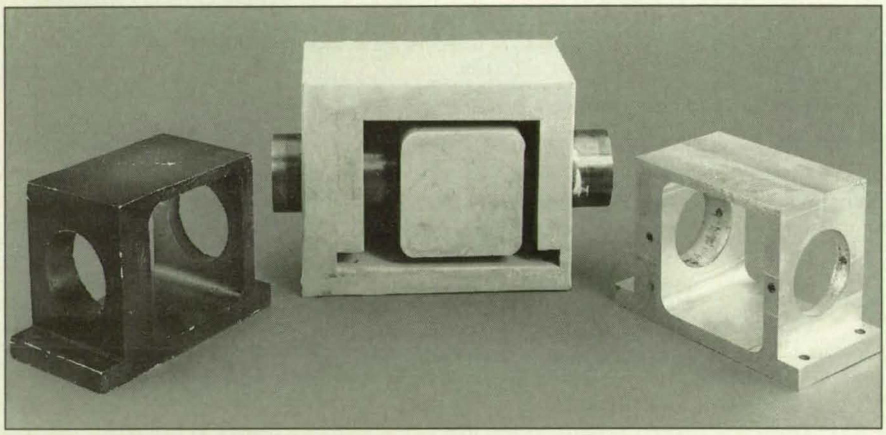


Figure 1. A **Dimensionally Stable Optical Mount** (left) is shown with a master pattern (right) and a silicone rubber mold (center).

Ceramic supports for optical components and benches offer important advantages over the usual metal parts. Ceramic materials expand and contract only slightly with changes in temperature. Moreover, they are relatively inexpensive and lightweight.

Nearly all optical components are mounted on supports and benches made of aluminum, stainless steel, or Invar (or equivalent) nickel/iron low-expansion alloy. Aluminum is lightweight, but expands and contracts significantly; its coefficient of thermal expansion at room temperature is 2.5×10^{-5}/°C. In optics, where precise alignments are essential, temperature-related dimensional changes can make a system inoperable. Stainless steel and Super Invar (or equivalent) have low coefficients of thermal expansion, about one-third and one-fifth, respectively, of that of aluminum; but they are heavy, expensive, and difficult to machine. In fact, much of the weight of optical systems is attributable to metal mounts.

Certain ceramics, on the other hand, have coefficients of thermal expansion lower than those of stainless steel and Invar, with density like that of aluminum, and they cost far less — about $10/lb (about $22/kg) versus $1,000/lb ($2,200/kg) for Invar and $50/lb ($110/kg) for aluminum (1992 prices). Ceramics expand and contract only negligibly with changes in temperature and can thus be slip cast at Langley Research Center without temperature control.

Dimensionally stable optical mounts (far left of Fig. 1) and benches (Fig. 2), have been fabricated using a slip-casting technique. Slip casting is defined here as a process that consists of a slip (ceramic powders dispersed in an aqueous media) being poured into a porous mold, which extracts a large percent of the liquid from the slip leaving a semisolid part.

Developing a porous mold requires that a master pattern of required dimension be machined from aluminum, which is inexpensive, lightweight and easy to machine (far right of Fig. 1). Extreme importance was placed on design and preparation of the master, since it is the most important item in producing the mold.

The first step in producing a slip cast ceramic part is to fabricate a silicone rubber mold (middle of Fig. 1). Silicone rubber was used as the mold material because the silicon acted as a release agent for the molded parts. Hot wax was poured into the mold to produce a wax master. A quality inspection (dimensional and visually) is performed on the wax master upon its removal from the mold.

The wax master is encapsulated in a moisture-absorbing compound. The wax is burned out, leaving a dimensional cavity equal to that of the master. A ceramic slip is poured into the cavity and allowed to jell (1 to 2 h) before removing the mold. Because the mold becomes more plastic with increasing water absorption, it can be peeled off of the green ceramic body, regardless of the ceramic body shape.

A note of caution: If the ceramic part is placed in the furnace before final drying, the remaining moisture will turn to steam, and its volume will increase several hundred times. This steam will generate tremendous pressure within the ceramic part and explode or crack. To avoid explosions or cracks, the air around the piece must be totally saturated with water vapor as the temperature is raised to remove remaining moisture. No sur-

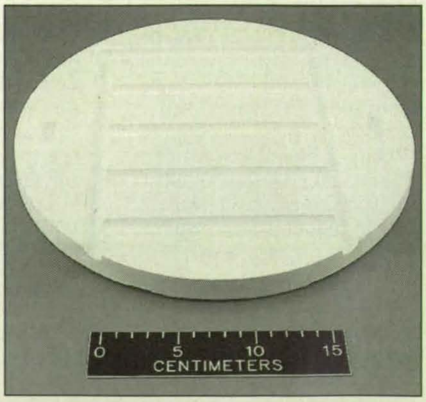


Figure 2. This **Ceramic Optical Bench** was fabricated via slip-casting technique.

face evaporation can then occur. After the piece has reached uniform temperature (below 100 °C), the relative humidity of the air around the piece can be slowly lowered to allow drying to occur.

Careful control of the temperature and humidity in the dryer is important. The dried piece is fired in a furnace, which can increase temperature at less than 1 °F/min (0.6 °C/min).

This work was done by Peter Vasquez, Robert L. Fox, and Stephen P. Sandford of **Langley Research Center.** *No further documentation is available.*
LAR-14948/LAR-14981

Optoelectronic Inclinometer

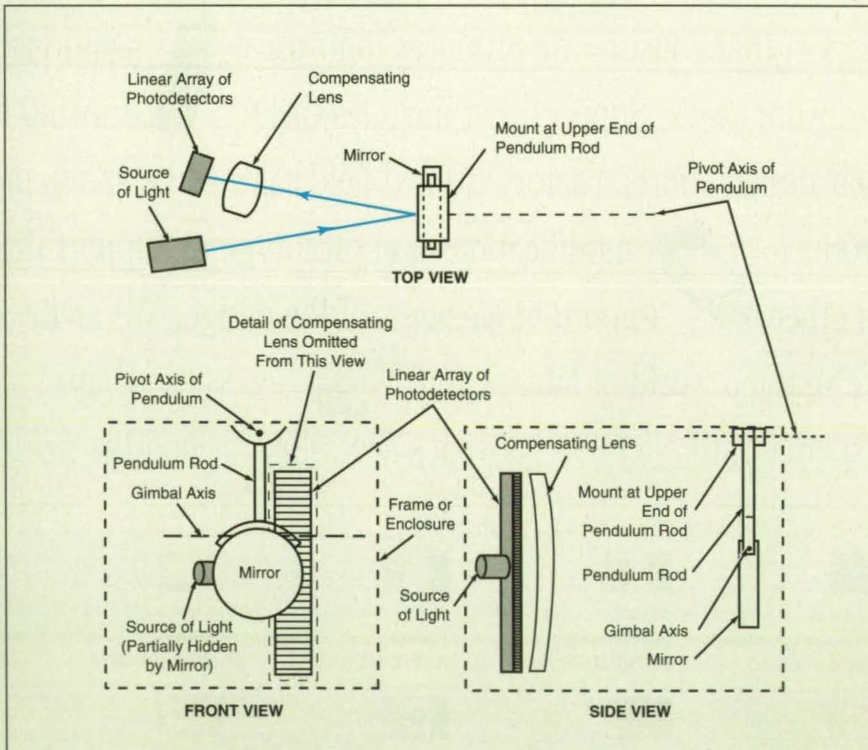
Tilt would be measured with respect to a vertical mirror.

Langley Research Center, Hampton, Virginia

A proposed optoelectronic instrument would measure the tilt of an object about a single horizontal axis by measuring the change of position and orientation of a laser beam reflected from a hanging mirror. The mirror would remain vertical while the rest of the instrument rotated with the object.

The instrument (see figure) would include a rectangular open frame mounted in the object, the tilt of which was to be measured. The mirror, made of heavy material or weighted, would be mounted in high-quality bearings in a gimbal that would, in turn, be held by a rod pivoted at its upper end. Thus, the rod, gimbal, and mirror taken together would constitute a pendulum. The frame or enclosure would be oriented so that the gimbal axis would be nominally parallel to the axis about which the tilt was to be measured, while the pivot axis of the pendulum would be nominally horizontal and perpendicular to the gimbal axis.

Acting via the combination of the pendulum and gimbal, gravitation would keep the mirror vertical when the frame tilted about either or both horizontal axes. A source of light (e.g., a laser diode or a light-emitting diode equipped with a collimating or focusing lens) would emit a beam that would be reflected from the mirror onto a linear array of photodetectors. The source of light would be oriented so that at zero tilt, both the beam of light from the source and the beam reflected by the mirror would lie in a horizontal plane,



The **Optoelectronic Inclinometer** would measure tilt about the gimbal axis by measuring the change in position and orientation of the beam of light reflected from the mirror hanging in the gimbal.

and the reflected beam would land at or near the midlength of the linear array of photodetectors. As the object and the instrument frame tilted about an axis parallel to the gimbal axis (pitch), the spot of light cast by the reflected beam would be translated along the array. Tilt of the object and instrument frame (about the pivot axis of the pendulum (roll)) would produce a small (second-order) change in the position of the spot with respect to the array, but this effect may be tolerable at small tilt angles. The maximum amount of tilt about the pivot axis of the pendulum that the instrument could tolerate would depend on the size of the mirror and the physical size of the linear array and the spacing of the components. A compensating lens could be included to correct for nonlinearity and to ensure that the beam continued to fall on the array throughout the desired angular range of the instrument.

This work was done by Timothy D. Schott of **Langley Research Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center; (804) 864-9260. Refer to LAR-14728.

More About Pressure Probes for Turbulent Flows

An array of probes yields data on static and total pressures and cross-stream turbulence.

Ames Research Center, Moffett Field, California

The figure illustrates an array of pressure probes for use in a turbulent stream of inviscid, incompressible fluid. The measurements of the probes in this array can be processed into time-averaged values of the static pressure, the total pressure based on the entire velocity, the stagnation pressure based on the time-averaged streamwise component of velocity (along which the probe tubes are required to be aligned), and cross-stream turbulence.

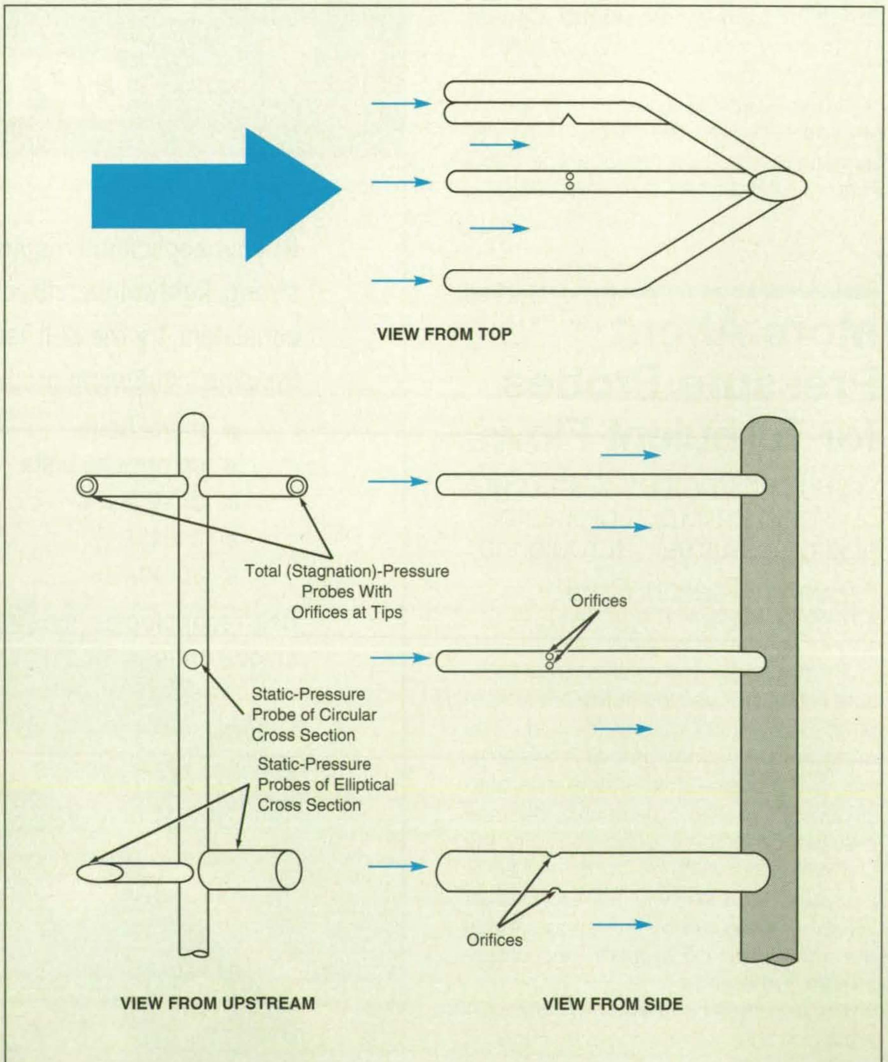
The array is a combination of the separate pressure-probe arrays described in "Measuring Streamwise Momentum and Cross-Stream Turbulence" (ARC-11934), *NASA Tech Briefs*, Vol. 16, No. 8, (August 1992), page 53, and "Probe Rakes To Measure Static Pressure and Turbulence" (ARC-12973), *NASA Tech*

Briefs, Vol.18, No.9, Sept.1994, page 106. To recapitulate: Each probe is designed by applying potential-flow theory to the flow field on and near its surface. An upstream-facing probe orifice can be shaped to sense the stagnation pressure based on the entire velocity or on one or more components of velocity — in this case, the streamwise component. An orifice on the side of the probe tube downstream from the tip can be positioned to sense a combination of static pressure and pressure attributable to cross-stream turbulence. The cross-sectional shape of a probe tube can be made elliptical, and the probe orifices positioned around the circumference in such a way as to increase or decrease, by a known factor, its response to one of the components of cross-stream turbulence.

The equations that express the directional responses of the various probes in the array can be solved together to eliminate unknown quantities; this makes it possible to process the digitized time-averaged probe readings together to obtain the time-averaged static, stagnation, and cross-stream-turbulence pressures. In the case of the five-probe array shown in the figure, one obtains the time averages of the two stagnation pressures, plus redundant values of the time-averaged static pressure and the time-averaged cross-stream-turbulence pressures.

This work was done by Vernon J. Rossow of **Ames Research Center.** *For further information,* ***write in 80*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-11935.



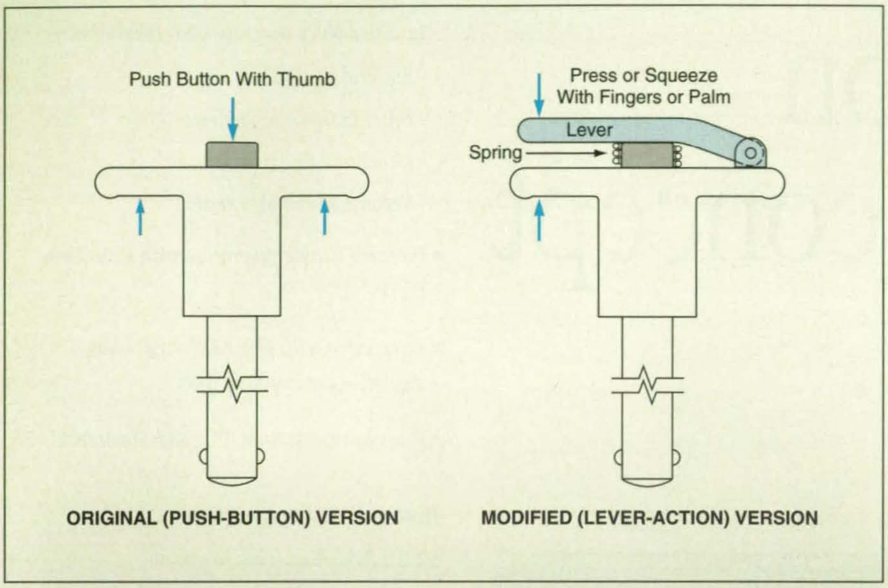
These **Five Pressure Probes** yield readings from which one can compute time averages of the entire and streamwise stagnation pressures, the static pressure, and the pressures associated with the two components of cross-stream turbulence. The three lower probes yield data that are redundant (in principle) and that could, therefore, be used to reduce errors.

Quick-Release Pin With Lever Action

The mechanism can be operated with a gloved hand.

Lyndon B. Johnson Space Center, Houston, Texas

The figure illustrates original and modified versions of a quick-release ball-detent pin with a T-handle. The original version is a commercially available mechanism called a "pip pin," and is released by pressing the button on the handle. The original version is advantageous in that it resists inadvertent actuation. However, it is disadvantageous in that the operator must exert a force on the button, usually by pressing on the button with a thumb while simultaneously grasping the T-handle with at least two other fingers; this can be difficult to do, especially when wearing a heavy glove.



The **Lever-Action Quick-Release** pin can be operated more easily; release can be effected with less force and with simpler gripping configurations that are more suitable for gloved hands.

In the modified version, a lever has been added to the handle to facilitate actuation. The lever action reduces the actuation force. In addition, one is no longer limited to use of a thumb and at least two fingers to exert the reduced actuation force; the lever-action pin can also be operated by squeezing on any point of the moveable ends of the lever and handle together between a thumb and forefinger or by simply grasping and squeezing the handle and lever with the entire hand in a more natural grasp. Tests showed that the modified release pin can be operated easily with a gloved hand.

This work was done by Robert C. Trevino of **Johnson Space Center.** *For further information,* ***write in 29*** *on the TSP Request Card. MSC-22398*

Calibration Valve With Built-In Test Port

Lyndon B. Johnson Space Center, Houston, Texas

A calibration valve includes a built-in test port for calibrating control-panel gauges in place, without having to remove them for calibration. The use of this valve reduces the number of plumbing parts and thus the number of potential leakage points. In addition, the application of the calibration valve saves time when calibrating the control-panel gauges or transducers and prevents damage or loss of the instruments by not having to remove them from the control panel for calibration.

This work was done by Carmine A. Pilichi of Rockwell International Corp. for **Johnson Space Center**. *For further information,* ***write in 85*** *on the TSP Request Card. MSC-22410*

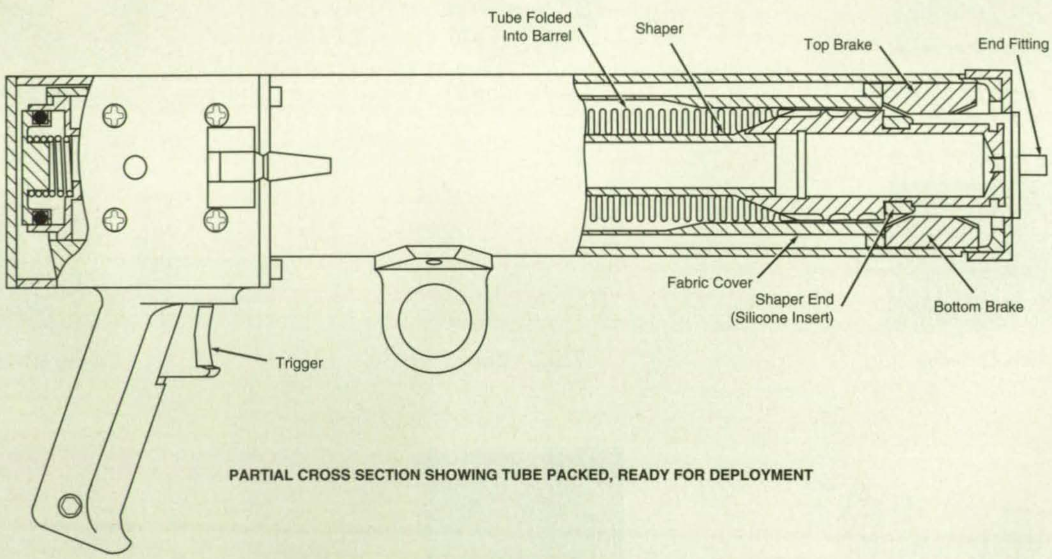
Machinery

Inflatable Pole

This portable device extends reach up to 20 ft (6 m).

Lyndon B. Johnson Space Center, Houston, Texas

An inflatable pole is a lightweight, portable tool for reaching an object at a height or across a gap. When not in use, the tool collapses to 3 to 5 percent of its inflated length. The pole was developed for use as a self-rescue device by an astronaut who becomes untethered outside a spacecraft: the astronaut would use the pole to reach a grapple on the spacecraft and pull to it. The pole might also be useful on Earth as a rescue device or in performing routine tasks like



PARTIAL CROSS SECTION SHOWING TUBE PACKED, READY FOR DEPLOYMENT

INFLATABLE POLE IN USE

Before Deployment, the inflatable tube is neatly pleated in the space between the shaper tube and the fabric sheath. After deployment, it extends stiffly from the barrel of the gun.

High-Tech Holiday **Gift** Ideas

1996 NASA Calendar

Each month features a full-color photo of the space shuttle in action. Includes historic launch dates from the 1960s to present.
$10.95

Astronaut Ice Cream/Sandwich

The perfect stocking-stuffer! Freeze-dried, vacuum-packed ice cream treats just like the ones enjoyed by astronauts in space. Two packages – an ice cream sandwich and a neopolitan ice cream mix – for just $5.95.

NASA Vector Cap

Red, white, and blue NASA logo on a high-quality white poplin cap. Size-adjustable. $9.95

Planets Sweatshirt

Striking color images of the 9 planets in our solar system. Quality white sweatshirt, adult sizes only: M, L, XL, XXL.
$19.95

Apollo 13 Commemorative T-Shirt

A great momento for space and movie buffs! Features a gorgeous full-color rendition of the official Apollo 13 mission emblem (the "Horses of Apollo") superimposed with dramatic effect on a black T-shirt.
Adult sizes: S, M, L, XL. $13.95

Spacecap "Pogs"

Limited edition collector Pogs feature official full-color logos of Mercury, Gemini, and Apollo missions, as well as the NASA vector logo. Order today – they will be gone tomorrow. $3.95

Order by November 30 for pre-Christmas delivery.

Rush me the following: (list quantity)

__ Planets Sweatshirt ($19.95)
circle size(s): M L XL XXL
__ Apollo 13 T-Shirt ($13.95)
circle size(s): S M L XL

__ 1996 NASA Calendar ($10.95)
__ NASA Vector Cap ($9.95)
__ Spacecaps ($3.95 per package)
__ Astronaut Ice Cream – 2 Packs ($5.95)

Add $5.00 to order for postage/handling. (NY residents add sales tax to total.)
Total: $ ____________

☐ check enclosed (payable to Associated Business Publications)

☐ charge my: ☐ VISA ☐ Mastercard ☐ AmEx
Account No. ____________
Expire Date ____________
Signature ____________

Name ____________
Company (if applicable) ____________
Address ____________
City/St/Zip ____________
Phone No. ____________ Fax No. ____________

Mail with payment to: Associated Business Publications, 317 Madison Avenue, Suite 921, New York, NY 10017.
Or fax (credit card orders) to (212) 986-7864. Questions? Call Demi at (212) 490-3999.

For More Information Write In No. 610

changing a high light bulb without a ladder.

The pole includes a 2-in.-diameter (10-cm-diameter) tube of urethane-coated Kevlar (or equivalent polyester) fabric. Before use, the tube is bunched on a shaper rod in a gas gun (see figure). To deploy it, a user presses the trigger of the gun releasing a regulated 30-psi (0.21-MPa) blast of nitrogen from a separate bottle. The gas inflates the tube. A fabric cover prevents snagging and ensures that the tube emerges straight.

The operator can stop deployment of the tube at any point up to its maximum 20-ft (6.1m) extension by releasing the trigger: this action applies the brakes on the gun barrel. The operator thus controls the length of the pole. Once deployed, the tube remains inflated and stiff while the operator uses It. The tube weighs only about 7 oz. (0.2 kg); thus, it has low inertia when extended, so that it can be maneuvered easily.

When the task with the inflatable pole has been completed, the operator opens a vent valve to deflate the tube. The operator then opens the gun, removes the fabric cover, and repacks the tube.

This work was done by Scott A. Swan of **Johnson Space Center**. *For further information,* ***write in 76*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-22244.

Estimating Vibrational Powers of Parts in Fluid Machinery

Vibrations of components are taken to be governed by local physics of flow.

Lewis Research Center, Cleveland, Ohio

In a new method of estimating the vibrational power associated with a component of a fluid-machinery system, the physics of flow through (or in the vicinity of) the component is regarded as governing the vibrations. The method was devised to generate scaling estimates for the design of new parts of rocket engines (e.g., pumps, combustors, nozzles) but is also applicable to terrestrial pumps, turbines, and other machinery in which turbulent flows and vibrations caused by such flows are significant.

The new method stands in contrast to several prior methods in which the vibrational powers associated with the components were estimated by scaling from global variables (e.g., engine thrust or exhaust velocity). In the new method, it is assumed that the scaling law is

$$\frac{G^2_{new}}{P_{s_{new}}} = \frac{G^2_{ref}}{P_{s_{ref}}}$$

where G^2 denotes the mean-square local vibrational power, P_s denotes the specific power (that is, the power per unit mass) of the pump or other component, the subscript "new" denotes the new component for which the estimate is sought, and the subscript "ref" denotes a similar preexisting reference component (e.g., a pump of similar, but not identical design), the vibrations of which have been measured.

The specific power of a pump or other component for use in equation is given by

$$P_s = \frac{KQ^3}{M}$$

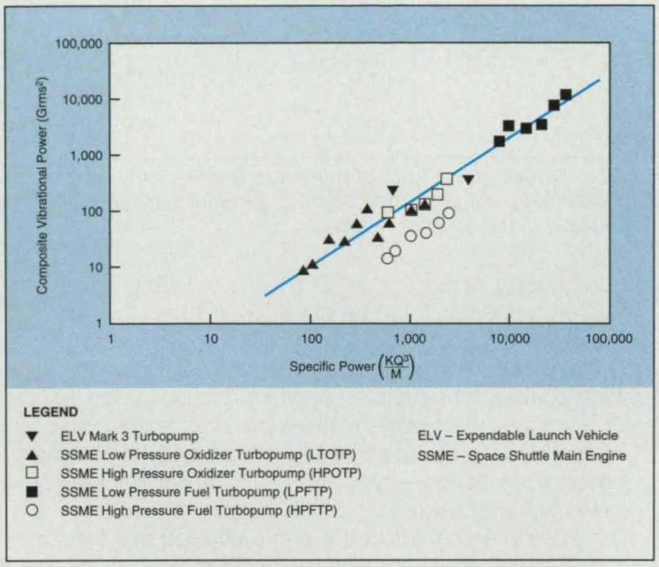
where K is a lumped parameter that summarizes the effects of the flow geometry in or about the component, Q is the volumetric flow rate, and M is the mass of the component. The lumped parameter is given by

$$K = \frac{\int_{x=0}^{x=x_f} \left[\frac{1}{A(x)}\right]^3 \frac{1}{L(x)} dx}{x_f}$$

where $A(x)$ = the local cross-sectional area presented to the flow at position x, $L(x)$ = the local characteristic length in the plane of $A(x)$ (e.g., separation between a pump impeller and pump housing) perpendicular to the flow, and x_f = the length of the flow path through the component.

Of course, this method of scaling is only approximate: strictly speaking, the use of K is valid only if the fluid has constant density (is incompressible). The validity of the method also depends on the assumption that the fluid flows quasi-steadily and that the flow gives rise to uncorrelated acoustic powers in different parts of the pump. Despite these limitations, when the method was applied to data from five different rocket-engine turbopumps, the processed data all lay near one straight line on a logarithmic plot (see figure).

This work was done by S. A. Harvey and L. C. Kwok of Rockwell International Corp. for **Lewis Research Center**. *For further information,* ***write in 10*** *on the TSP Request Card. LEW-15194*



Data Pertaining to Five Turbopumps under various operating conditions cluster around a line that approximates the new scaling law.

Testing and Analysis of Rubbing of Turbine-Blade Tips

A combination of established techniques has been applied to a modern design problem.

Marshall Space Flight Center, Alabama

A unique combination of established techniques of experimentation and theoretical analysis has been devised to study the stresses induced in turbine blades by intermittent or periodic rubbing of the tips of the blades in turbine housings. Rubbing is an inevitable consequence of modern high-speed, high-efficiency turbine designs, which call for blade-tip clearances to be as small as possible: this is because thermal and centrifugal growth of blade-tip radii during operation sometimes reduces the already small blade-tip clearances to zero. It is necessary to quantify the stresses caused by rubbing in order to predict the fatigue lives of the blades.

In the initial application, the theoretical analysis involved time-domain numerical simulation of the responses of the blade to various rubbing excitations. For this purpose, the blade was represented by a conventional, linearly responding finite-element mathematical model. The simulated rubbing excitation was a once-per-revolution half sine pulse of tangential force at the blade-tip/housing seal interface, with a duration equal to

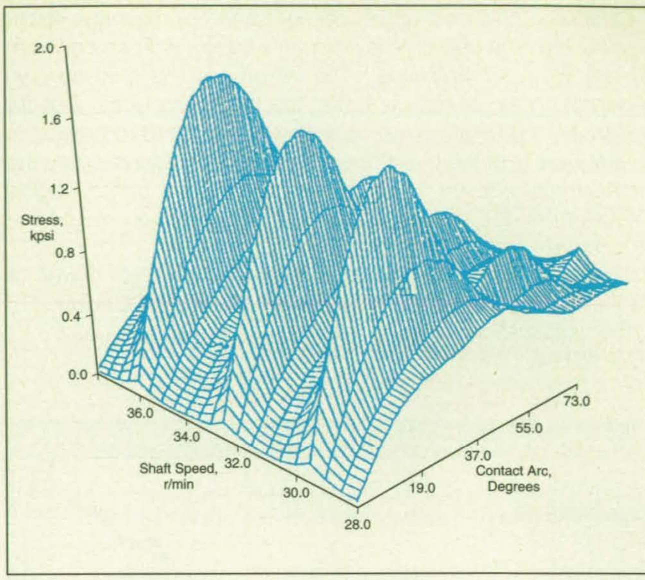


Figure 1. **Stress at the Root of the Blade Shank** was computed as a function of speed and contact arc in a parametric numerical-simulation study of the dynamic response.

the tip/housing contact time. Between excitatory pulses the simulated tangential force on the tip was zero.

In a parametric study, these computations were performed to map the response of the blade as a function of the length of the rubbing-contact arc and the speed of rotation of the turbine shaft. For each pair of values of these parameters, the simulation of dynamic response was continued until a steady-state dynamic motion was reached — typically in 30 to 40 revolutions. Figure 1 shows some of the results of this parametric study.

The experimental part of the effort involved the construction of a unique testing apparatus (see Figure 2). A turbine rotor was instrumented with strain gauges on its blades, and slip rings were used to pass the outputs of the gauges to external tape recorders. A simulated tip-seal segment of a housing was connected to a hydraulic actuator coupled with a control system and a displacement transducer. The motion of the tip-seal segment could thus be controlled precisely. In the tests, the turbine was driven at speeds up to 32,700 r/min. and the tip-seal segment was moved in to effect rubbing contact for short periods of time. The results of tests verified analytical predictions that the dynamic behavior consists of once-per-revolution rubs alternating with periods of free vibrations.

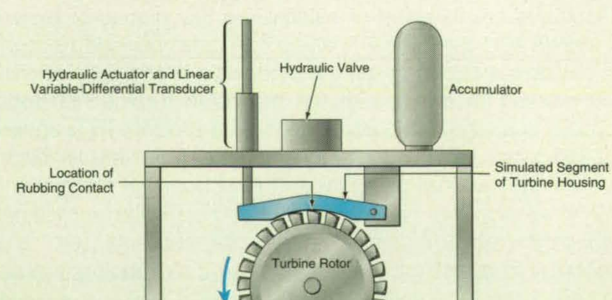


Figure 2. This **Testing Apparatus** simulates blade-tip rubbing and measures the dynamic responses of the blades.

This work was done by Gary A. Davis and Ray C. Clough of Rockwell International Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 110*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-29981.

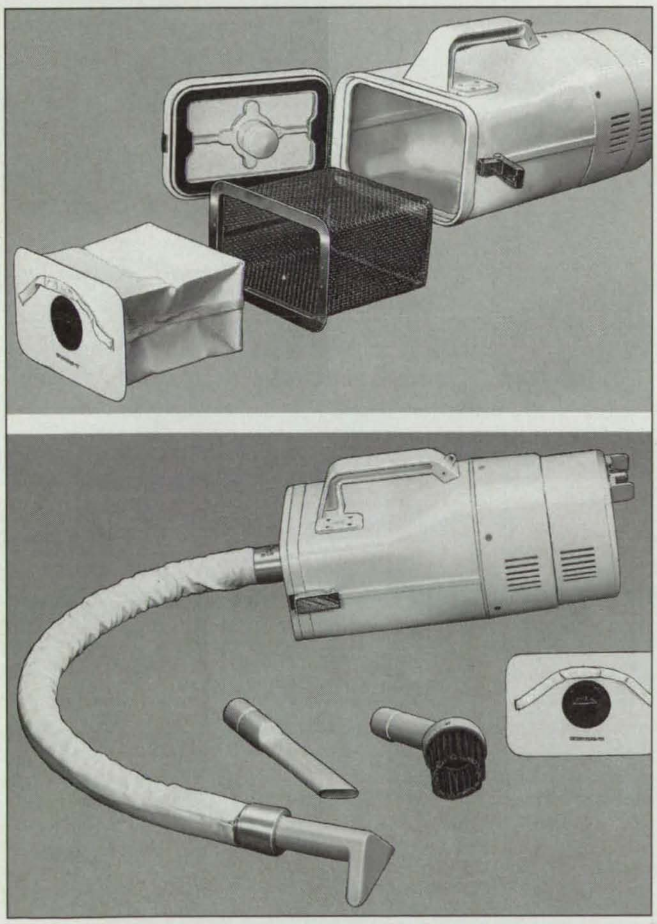
Wet/Dry Vacuum Cleaner

A hydrophobic bag with an absorbent pad retains water and dust.

Lyndon B. Johnson Space Center, Houston, Texas

The vacuum cleaner collects and retains dust, wet debris, and liquids. Designed for housekeeping on Space Station *Freedom*, it functions equally well in normal Earth gravity or in microgravity. It generates acoustic noise at comfortably low levels and includes circuitry that reduces electromagnetic interference to other electronic equipment.

The vacuum cleaner (see figure) draws materials into a bag made of a hydrophobic sheet with layers of hydrophilic super-absorbing pads at the downstream end material. The hydrophobic sheet lets air, but not liquid, leave the bag, while the hydrophilic material gels the liquid to retain it after the vacuum cleaner has been turned off. The hydrophilic material can gel many



The **Molded Polycarbonate Case Houses** the other components of the vacuum cleaner. The hose is made of silicone rubber covered with Nomex fabric.

times its own weight of liquid. The bag holds dust particles larger than 40 mm and absorbs up to 48 oz (1.42 L) of liquid.

Suction is developed by a two-stage blower driven by a modified commercial 120-Vdc motor. The two stages help to keep noise low. The blower also provides a secondary airflow to cool its electronic components.

This work was done by Harold Reimers of **Johnson Space Center** *and Jay Andampour, Craig Kunitser, and Ike Thomas of Lockheed Engineering & Sciences Co. No further documentation is available. MSC-22044*

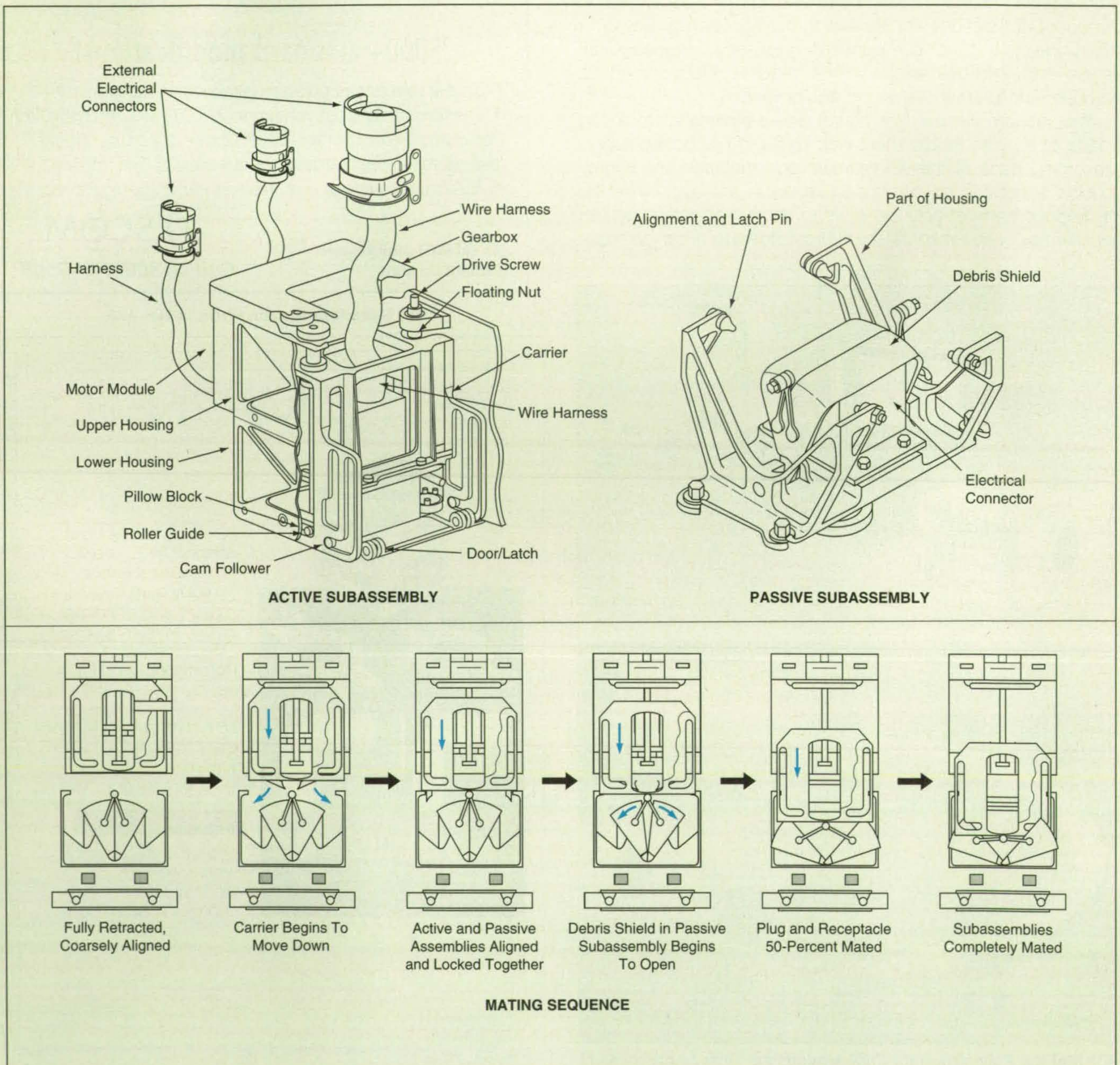
Shielded, Automated Umbilical Mechanism

Fluid and/or electrical connectors are protected against debris.

Lyndon B. Johnson Space Center, Houston, Texas

An umbilical mechanism automatically connects and disconnects various fluid couplings and/or electrical contacts while shielding the mating parts from debris. The mechanism reacts mating and demating loads internally, without additional supporting structures.

The mechanism is designed for service in outer space, where its shields would protect against micrometeoroids, debris, ultraviolet radiation, and atomic oxygen. It could be used on Earth to



The **Active Subassembly Mates** with the passive subassembly of the umbilical mechanism.

connect or disconnect fluid or electrical utilities in harsh environments like those of nuclear powerplants or undersea construction sites, or in the presence of radioactive, chemical, or biological hazards, for example.

The mechanism consists of an active and a passive subassembly. It can accommodate an initial linear misalignment of 0.250 in. (6.35 mm) and angular misalignment of 2° between the subassemblies.

The mating sequence consists of the following steps (see figure):

1. The active subassembly with its connector retracted is coarsely aligned relative to the passive subassembly.
2. A carrier in the active subassembly begins to move a plug down as a cam action opens the debris shields in this subassembly.
3. The active and passive subassemblies are precisely aligned and locked together by a pin-and-drogue device.
4. Acting via a cam and linkage, the carrier in the active subassembly begins to open the debris shield of the passive subassembly.
5. When the debris shield in the passive subassembly is completely open, the plug attached to the active subassembly is 50-percent mated with a receptacle in the passive subassembly.
6. The carrier continues to extend the plug until it is completely mated with the receptacle.

All functions — extension of the plug, mating, and movement of the debris shields — are actuated by a single motor. If the mechanism jams or fails at any point in the sequence, an override feature in the drive train allows manual operation. The plug and receptacle in the mechanism can readily be changed between fluid-transfer and electrical applications.

This work was done by Daniel R. Barron, Brion F. Morrill, and Vytas Jasulaitis of McDonnell Douglas Corp. for **Johnson Space Center**. *For further information,* ***write in 99*** *on the TSP Request Card.*

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act {42 U.S.C. 2457 (f)} to McDonnell Douglas Corp. Inquiries concerning licenses for its commercial development should be addressed to:

John Scholl, Counsel
McDonnell Douglas Corp.
5301 Bolsa Avenue
Huntington Beach, CA 92647
(714) 896-5999

Refer to MSC-22053, volume and number of this NASA Tech Briefs *issue, and the page number.*

Sinterless Fabrication of Contact Pads on InP Devices

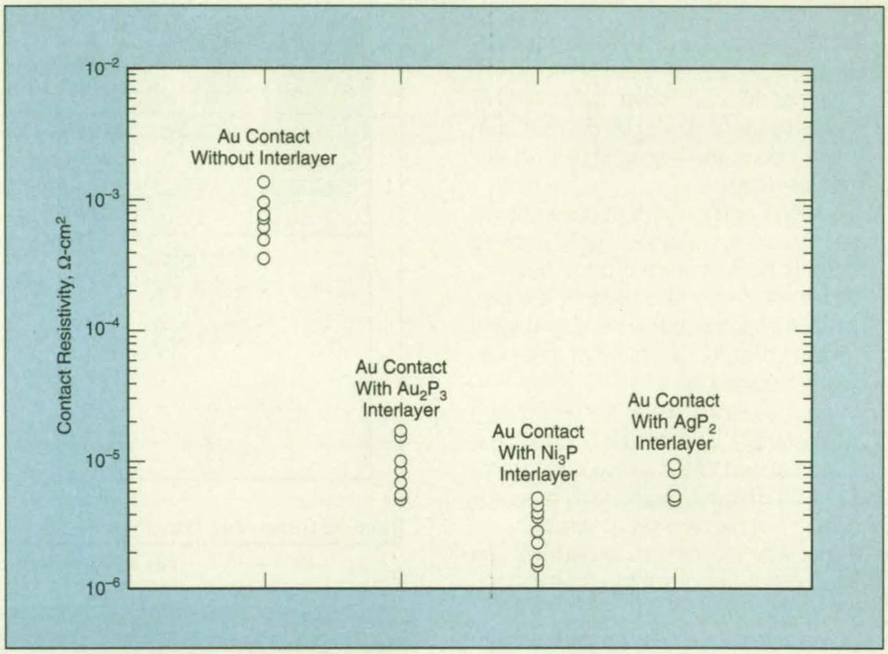
Carefully chosen contact materials are used.

Lewis Research Center, Cleveland, Ohio

Research has shown that with a proper choice of material, low-resistance contact pads can be deposited on solar cells and other devices by an improved technique that does not involve sintering. Until now, sintering has been used and has often proven destructive to the devices being fabricated.

To make low-resistance electrical contact to an InP semiconductor device according to the prior technique, contact metal is deposited on the semiconductor, then the contact metal must be sintered at high temperature. Although the sintering step desirably reduces the contact resistance, it also undesirably induces substantial interdiffusion between the metal and the InP substrate. Unless carefully controlled by imposition of diffusion barriers or by use of such techniques as rapid thermal processing, this interdiffusion can quickly degrade or destroy the device. Such shallow-junction devices as junction field-effect transistors and solar cells are particularly susceptible to damage during formation of contacts.

Research directed at understanding the mechanisms involved in the contact-sintering process has resulted in the identification of a special group of materials that includes the phosphides of gold, silver, and nickel; specifically, Au_2P_3, AgP_2, and Ni_3P. The introduction of one of these materials between an underlying n-doped InP semiconductor and an overlying current-carrying metal layer results in low contact resistance. Further research has indicated that only a very thin interlayer of any of these compounds is needed to obtain low contact resistance, without having to subject the contact to the destructive sintering process.



The **Incorporation of a Phosphide Interlayer** substantially reduces the resistivity between a gold current-carrying layer and an indium phosphide substrate.

Phosphide layers with thicknesses of the order of 20 to 30 Å on moderately doped InP are sufficient to make contact resistivities range downward to as little as 10^{-6} Ω-cm^2 (see figure). These values are only slightly greater than those obtained by use of the destructive sintering process.

This work was done by Victor G. Weizer of **Lewis Research Center,** *Navid S. Fatemi of Sverdrup Technology, Inc., and Andras L. Korenyi-Both of Calspan Corp. Further information may be found in NASA TM-105670 [N92-24802/TB], "Sinterless Contacts to Shallow Junction InP Solar Cells."*

Copies may be purchased [prepayment required] from the NASA Center for AeroSpace Information, User Services Division, Linthicum Heights, Maryland, Telephone No. (301) 621-0394. Rush orders may be placed for an extra fee by calling the same number. LEW-15863

Wax Reinforces Honeycomb During Machining

Wax-filled honeycomb can be cut to a precise contour on a lathe.

Langley Research Center, Hampton, Virginia

A method of machining on a conventional metal lathe has been devised for precise cutting of axisymmetric contours on honeycomb cores made of composite (matrix/fiber) materials. The method was devised because, heretofore, the fragility of these materials in their as-manufactured, unrestrained condition has made contouring difficult.

Composite honeycomb core materials exhibit high stiffnesses at low densities. Their composition and properties often make them the materials of choice for sandwich constructions in which composite face sheets are used. Some applications of these materials involve rigorous geometric tolerances. An example of such an application is as a core mate-

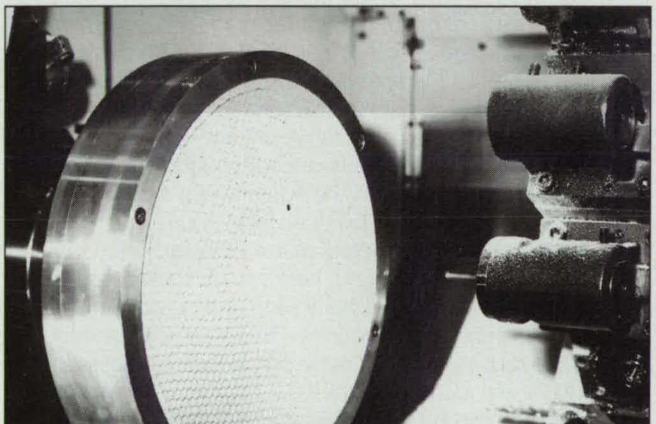
rial in a precise composite reflector panel.

Machining of honeycomb materials on multiaxis milling machines is possible, but achievable surface accuracies are limited by the lower positioning accuracies generally associated with milling machines as compared with those of metal lathes. Also, corrections for tool geometries must be made as functions of cutting angles. Lathe turning generally provides accuracies higher than those obtained with milling machines, because of the smaller number of axes on which the cutting tool of a lathe must move. Also, the simple point geometry of the lathe cutting tool eliminates the need for geometric correction for the cutting angle.

The innovative method of machining on a lathe involves a preparation in which the honeycomb is placed in an appropriate fixture and the fixture is then filled with a molten water-soluble wax. A number of different waxes have been tried. Saunders Yellow™ water-soluble wax was found to work well; others may also work. (The identity of this particular wax is given for completeness only and does not constitute an endorsement, expressed or implied, by the NASA Langley Research Center.)

During filling of the fixture, the upper surface of the wax should be kept fluid and allowed to solidify last to reduce the formation of voids: this can be done by occasional application of heat to the surface with a hot-air gun. Shrinkage associated with the solidification of the wax causes additional molten wax from the top to be drawn down into the cells of the honeycomb. The wax serves both to fasten the honeycomb to the fixture and to support the individual honeycomb cells during the machining process.

The figure shows a wax-filled low-density graphite/phenolic honeycomb in a fixture positioned on a numerically controlled lathe for machining of a paraboloidal contour. A computer program was written to generate coordinates along the desired parabolic contour based on the focal length of the paraboloid.



The **Wax Filling** reinforces the honeycomb walls against bending and tearing while the honeycomb is being contoured on a lathe.

The fixture that contains the wax-filled honeycomb is rotated, and the parabolic contour is cut with a tungsten carbide tool.

The fixture consists of an aluminum sleeve 15 in. (38.1 cm) in diameter mounted on a backplate. The backplate includes a mount for attachment to the lathe. The sleeve is symmetric about its midplane and can be reversed and remounted to the backplate during an interruption of the machining process. In this way, convex and concave parabolic contours are machined on either side of the honeycomb. To ensure that the resulting parabolic contours remain concentric and parallel, the back-

plate is not removed during the machining process. The metal lathe shown in the figure has a specified machining accuracy of ±0.0005 in. (about ±0.01 mm).

After machining, the wax-filled honeycomb is sawn from the aluminum fixture, then placed in hot water to remove the wax, then rinsed for 10 min in dilute (0.5 weight percent) hydrochloric acid at room temperature. The honeycomb is then washed with deionized water and dried.

This work was done by Timothy W. Towell, David T. Fahringer, Peter Vasquez, and Alan P. Scheidegger of **Langley Research Center.** *No further documentation is available. LAR-14927*

Improved Hermetic Feedthrough Seals for Optical Fibers

Inorganic sealing materials withstand widely ranging temperatures.

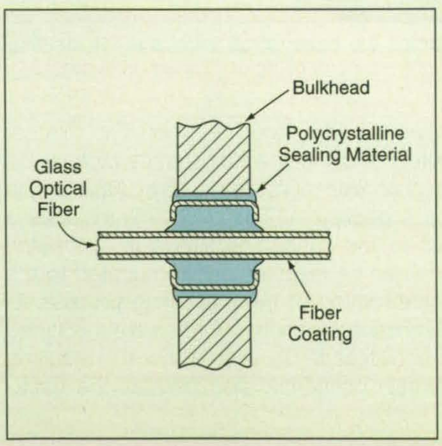
Lewis Research Center, Cleveland, Ohio

Improved hermetic feedthrough seals for optical fibers can withstand temperatures from as low as −325 °F (about −198 °C) to as high as 392 °F (about 200° C) while maintaining a helium leak rate of below 10^{-11} cm^3/s. This feedthrough material was used in an optical connector design targeted to meet the specifications of the space shuttle main engine environment as well as the expected environment of space-based rocket engines. The seal was demonstrated to perform exceptionally through salt spray, sinusoidal and random vibrations (20 to 2000 Hz), mechanical shock (40 g's) thermal shock at the extreme temperatures, humidity, and radiation (neutron fluence, gamma, and ion) testing.

The figure depicts a simplification of a feedthrough of the improved type, for illustrative purposes. Polyimide buffered glass/glass fibers are hermetically sealed to the feedthrough unit with the polycrystalline ceramic material. The sealing technology was demonstrated in two feedthrough types: a continuous fiber type as shown in the figure and a type where one end of the fiber is terminated with an SMA connector mate. The latter type may be constructed with a standard MIL-C-38999 Series 3 or 4 bulkhead-mound, hermetically sealed receptacle.

Throughout the environmental testing, the optical signal passing through the units was monitored. The prototype feedthroughs passed the required tests with negligible insertion losses.

This work was done by Robert Jui-Lin Fan of LiteCom, Inc., for **Lewis Research Center**. *For further information,* ***write in 120*** *on the TSP Request Card. LEW-15417*



This **Feedthrough Seal on an Optical Fiber** can be made primarily or entirely of inorganic materials that withstand widely ranging temperatures.

Level Indicator on a Tubular Inside Micrometer

Leveling helps to ensure accurate measurements.

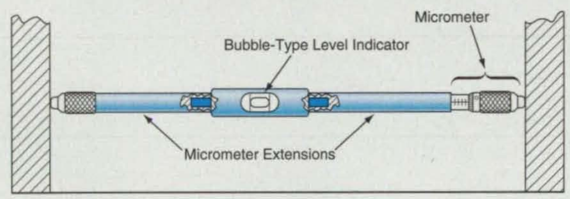
Marshall Space Flight Center, Alabama

A bubble-type level-indicating attachment on a tubular inside micrometer (see figure) helps a novice user obtain accurate measurements. The attachment can be helpful because in some situations that involve measurement of large, tight-tolerance inside dimensions, inside micrometers that are not held level between the contact point can give inaccurate readings.

A bubble-type level indicator is modified for use in this application by grinding it to a known length. The modified level indicator is then attached to the tubular inside micrometer by threading it into micrometer extensions that are attached to the graduated thimble of the micrometer.

The user adjusts the position and orientation of the micrometer and verifies that it is level by observing the bubble in the level indicator. Upon feeling the correct drag between the micrometer tips and the workpiece, the user can be confident that the tool is being used correctly and an accurate measurement has been obtained.

This work was done by R. Michael Malinzak and Gary N. Booth of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available. MFS-30026*



The **Level Indicator** helps to ensure accurate readings of a tubular inside micrometer when accuracy depends on keeping the micrometer horizontal.

Pressurized Bladder To Secure a Tile During Bonding

John F. Kennedy Space Center, Florida

An apparatus for use in installing tiles with adhesive includes an inflatable bladder that holds a tile in place while the adhesive cures. Once the tile is placed in the desired position, the pressurized bladder is pressed against the tile with increasing force until the pressure in the bladder equals the desired tile bond pressure. A pressure gauge that can be monitored easily from a distance is used to ensure that the tile is being held with the proper force during curing.

This work was done by John M. Hutchinson of Lockheed Space Operations Co. for **Kennedy Space Center**. *For further information,* ***write in 35*** *on the TSP Request Card. KSC-11662*

Discrete Gabor Filters for Binocular Disparity Measurement

Binocular disparities would be determined from phases of discretized Gabor transforms.

Lyndon B. Johnson Space Center, Houston, Texas

Discrete Gabor filters have been proposed for use in determining the binocular disparity — the difference between the positions of the same feature or object depicted in stereoscopic images produced by two side-by-side cameras aimed in parallel. The magnitude of the binocular disparity can be used to estimate the distance from the cameras to the feature or object. In one potential application, the cameras would be charge-coupled-device video cameras in a robotic vision system, and binocular disparities and the distance estimates would be used as control inputs — for example, to control approaches to objects to be manipulated or to maintain safe distances from obstacles.

The major problem in determining the binocular disparity is to match corresponding features in the two images. Typical prior solutions have been computationally intensive and have often included explicit (and sometimes error-prone) feature-matching processes. In the proposed solution, no attempt is made to identify or match features explicitly. Instead, one matches features implicitly and obtains the binocular disparity by computing complex Gabor transforms (see Figure 1) of corresponding neighborhoods in the two images, then taking advantage of the fact that the phase shift between the Gabor transforms is proportional to the local binocular disparity in approximately the same way in which a phase shift in a Fourier transform of the entire image is proportional to a uniform lateral shift in the entire image. Characterizing this approach from another perspective, the local binocular disparity is computed directly from a locally computed parameter of the pair of images, and no formal matching process is needed.

In practice, it is necessary to compute the Gabor transforms by use of relatively coarse-grained two-dimensional filters or masks, each pixel of which approximates the value of the even or odd Gabor function at its position (see Figure 2). The size of

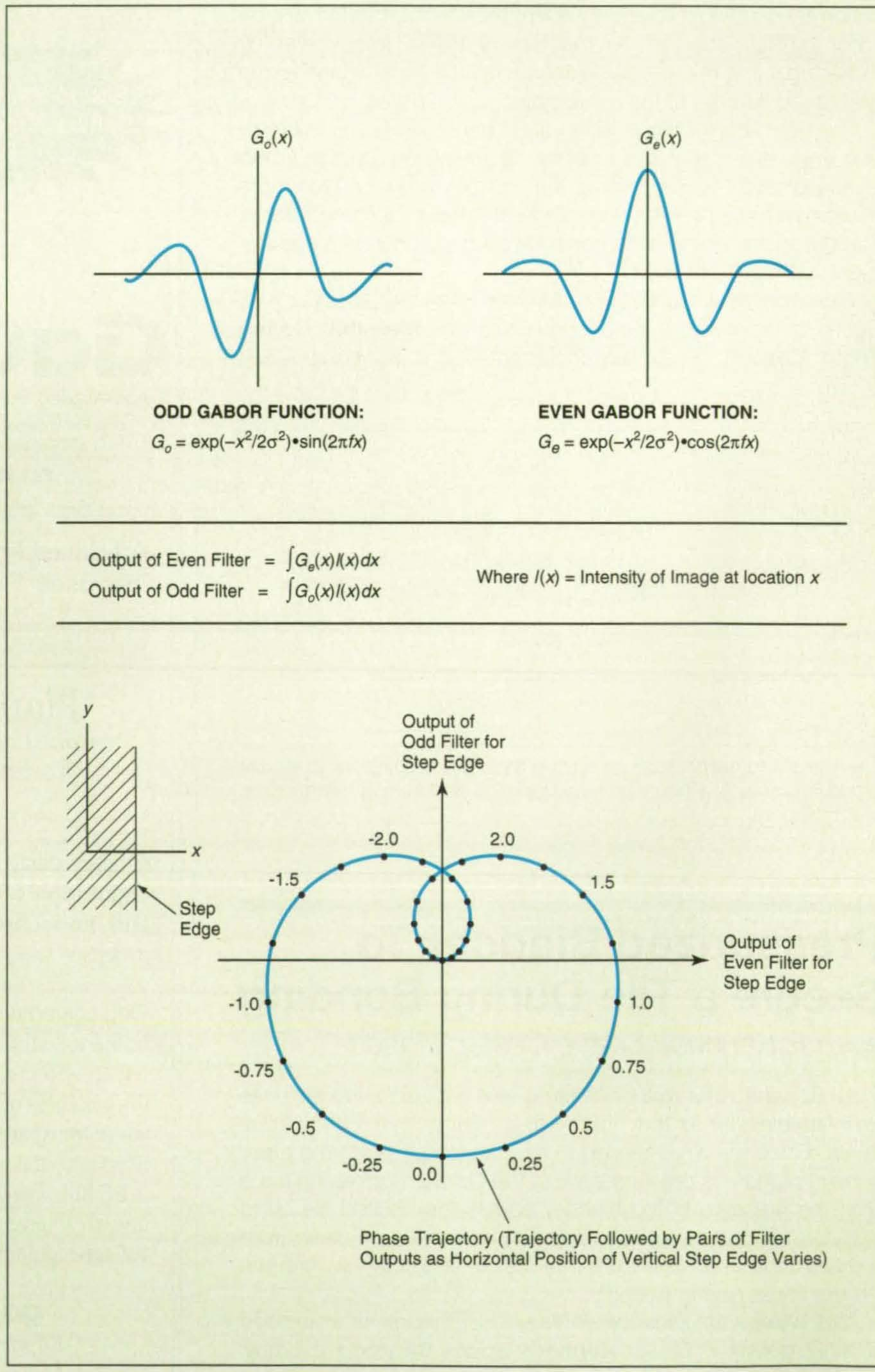


Figure 1. The **Even and Odd Gabor Functions** are used to compute complex Gabor transforms. The location of a feature (in this case, a step edge) can be determined from the phase of its complex Gabor transform.

the filter is optimized at 8 × 8 pixels on the basis of several conflicting considerations that include the need to obtain adequate resolution consistent with the pixel spacing, minimize the amount of computation, and minimize ambiguity in interpreting the output of the filter.

The filters are applied as follows. The two images are divided into corresponding windows of 8 × 8 pixels each. The even Gabor filter is overlaid on each window. The brightness at each pixel is multiplied by the filter value at that pixel. The sum of the brightness•filter products of the window is a single number and constitutes the filter output for that window. The odd Gabor filter is then overlaid on each window, and the process is repeated. The phase of the approximate Gabor transform of each window can then be obtained easily from the relative values of the even- and odd-filter outputs, and the phases of the transforms of the corresponding windows in the two images can be compared to obtain the phase shift and, hence, the local binocular disparity.

This approach involves less computation than do prior approaches based on convolution. In this approach, each 8 × 8 filter is applied only once to each 4 × 4 pixel neighborhood; in a convolution-based approach with a filter of equal size, it would be necessary to apply that filter to each 4 × 4 pixel neighborhood 16 times. This makes possible a considerable reduction in computation time and/or a reduction in the complexity of image-processing circuitry — important considerations in robotic systems.

This work was done by Carl F. R. Weiman of Transitions Research Corp. for ***Johnson Space Center****. For further information,* ***write in 111*** *on the TSP Request Card. MSC-22094*

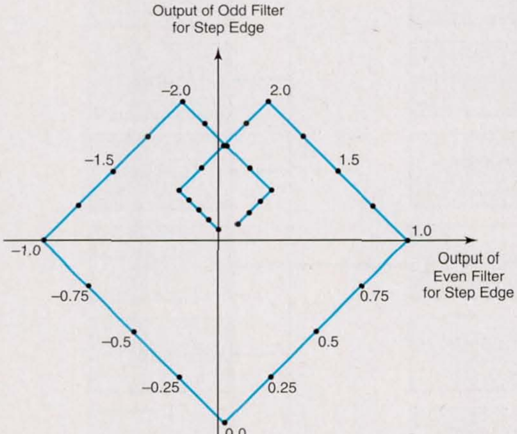
0	2	–4	–5	5	4	2	0
2	5	–8	–10	10	8	5	–2
4	8	–12	–16	16	12	8	–4
5	10	–16	–21	21	16	10	–5
5	10	–16	–21	21	16	10	–5
4	8	–12	–16	16	12	8	–4
2	5	–8	–10	10	8	5	–2
0	2	–4	–5	5	4	2	0

Odd

0	–2	–4	5	5	–4	–2	0
2	–5	–8	10	10	–8	–5	–2
4	–8	–12	16	16	–12	–8	–4
5	–10	–16	21	21	–16	–10	–5
5	–10	–16	21	21	–16	–10	–5
4	–8	–12	16	16	–12	–8	–4
2	–5	–8	10	10	–8	–5	–2
0	–2	–4	5	5	–4	–2	0

Even

8X8 DISCRETE GABOR FILTERS SENSITIVE TO VERTICAL EDGES



PHASE TRAJECTORY FOR STEP EDGE COMPUTED WITH 8X8 DISCRETE GABOR FILTER

Figure 2. The **Gabor Functions Are Approximated** by 8 × 8-pixel filters. The phase trajectory shown here is of the complex Gabor transform of a step edge, except that here it is computed approximately by use of the discrete filter instead of exactly as in Figure 1. The numbers and dots on the trajectory denote horizontal (x) position of the step edge in pixel units. Note that subpixel resolution is achieved readily.

Automated Diagnosis of Conditions in a Plant-Growth Chamber

Expert-system software advises nonexpert technicians about how to respond to malfunctions.

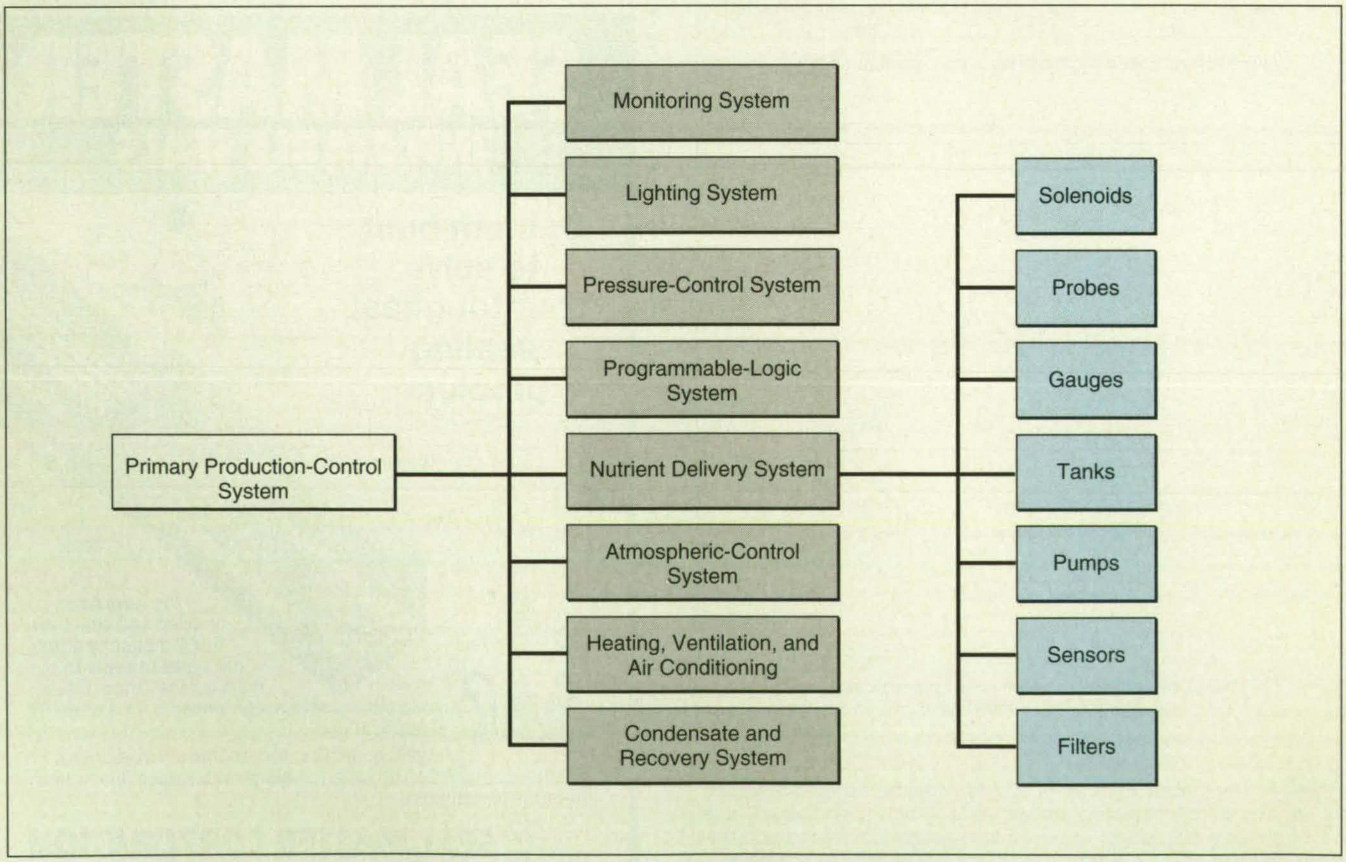
John F. Kennedy Space Center, Florida

The Biomass Production Chamber Operations Assistant software and hardware constitute an expert system that diagnoses mechanical failures in a controlled-environment hydroponic plant-growth chamber and recommends corrective actions to be taken by technicians. The plant-growth chamber and the expert system are subjects of continuing research directed toward the development of highly automated closed life-support systems aboard spacecraft to process animal (including human) and plant wastes into food and oxygen. The development of larger terrestrial biomass-production and -recycling systems might also benefit from this research.

The chamber and associated equipment (see figure) provide 200 ft^2 (18.6 m^2) of plant-growth area with controlled light levels, temperature, humidity, airflow, air composition, nutrient solution, temperature, pH, electrical conductivity, and chemical composition. Wheat, soybeans, lettuce, potatoes, and strawberries have been grown in the chamber. For purposes of this research, the knowledge base of the expert system concentrates on wheat crops. The knowledge base incorporates expertise from multiple expertise domains, including biology, electrical engineering, mechanical engineering, and chemistry. The knowledge base was developed by a group of experts in these fields and in information systems, using the techniques of knowledge engineering.

The system uses a Microsoft Windows interface to give technicians intuitive, efficient access to critical data. By selecting an icon on the Windows display, a technician can analyze a set of data, view operating equipment through closed-circuit television, cause the expert system to begin a diagnostic procedure, examine technicians' work schedules, or command the system to perform a computational simulation.

In the diagnostic mode, the system prompts a technician for information. For example, if a malfunction occurs in the nutrient-delivery system, the expert system asks for the time, location, and type



The **Nutrient-Delivery System** is one of several complex equipment systems that provide conditions favorable to the growth of plants. The expert system recommends responses to malfunctions in the nutrient-delivery system. Plans for the future call for extension of the expert system to respond to malfunctions in all the equipment systems.

of malfunction; the status of backup nutrient-delivery pumps; the type and the stage of growth of the crop; the visible amount of water in the plant trays; the ability to reduce the temperature; and the ability to turn lights on or off. When the expert system has enough information, it generates a recovery plan.

The recovery plan not only gives instructions for how to correct the malfunction, but also indicates steps to minimize damage to the crop in the interim; this is an important feature because a malfunction can usually be diagnosed in a few minutes, but a few hours may be needed for repairs. For a nutrient-delivery failure, the expert system might advise such emergency measures as turning off lights, reducing the temperature of the air, and closing drains on plant trays to reduce the metabolic rate of the plants and conserve the remaining nutrient solution. For each measure, and for combined measures, the expert system estimates the time available before serious damage occurs. For a prolonged failure, the system may even advise that the crop be replanted.

This work was done by Barry R. Clinger and Alfred L. Damiano of McDonnell Douglas Corp. for **Kennedy Space Center.** *For further information,* ***write in 9*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-3017. Refer to KSC-11761.

Predatory Microorganisms Would Help Reclaim Water

Pathogenic microorganisms would be removed from water without use of harsh chemicals, intense heat, or ionizing radiation.

Marshall Space Flight Center, Alabama

Wastewater-reclamation systems of a proposed type would use predatory, nonpathogenic microorganisms to consume pathogenic microorganisms. The predators in question are *Dictyostelium* amoebae, which consume bacteria (and presumably, could also be induced to eat microalgae, viruses, and protozoa). The *Dictyostelium* amoebae convert their prey into their own cell substance, which is largely cellulose. *Dictyostelium* is not harmful to humans, other macroscopic animals, or macroscopic plants. The cellulosic product could be subjected to further biodegradation or other treatment. Unlike some other wastewater-reclamation systems, these systems would not require the use of toxic chemicals, intense heat, or ionizing radiation (γ rays or ultraviolet) to destroy microorganisms.

Two apparatuses have been constructed to test the concept. One of them includes a growth chamber that contains an 18-in. (45.7-cm)-diameter rotating plate, on which petri dishes are placed. Each dish contains *Dictyostelium* growing on agar and a porous stainless-steel disk inoculated with bacteria and amoebae. The dishes are illuminated by two lamps, which provide constant simulated sunlight to induce growth of cellulosic *Dictyostelium* stalks. The plate is slowly rotated so that all samples are exposed equally to the light. The air in the growth chamber is kept at high humidity by circulating it between the growth chamber and an auxiliary chamber in which water is sprayed. No special equipment is needed to keep the temperature in the growth chamber within an acceptable range.

The other apparatus includes two connected 5-gal (19-L) plastic tanks, one of which serves as a reactor vessel, while the other serves as a holding tank. The reactor vessel contains a

mixing paddle composed of four vertical panels. Tubes are mounted in the reactor vessel to take samples at four levels. An industrial wastewater-reclamation system is more likely to be based on this apparatus than on the first-mentioned apparatus.

This work was done by Morris A. Benjaminson of North Star Research, Inc., and Stanley Lehrer of Electro-Optics Devices Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 77*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26321.

Chamber Design for Slow Nucleation Protein Crystal Growth

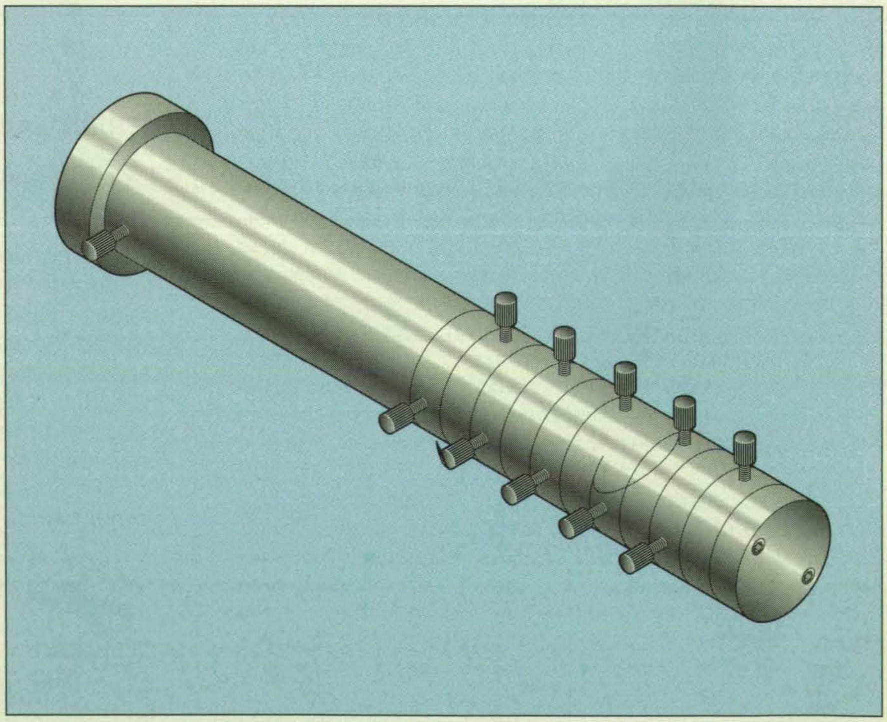
New design provides gradation of nucleation and growth rates.

Marshall Space Flight Center, Alabama

A multiple-chamber dialysis apparatus (see figure) grows protein crystals on Earth or in microgravity with a minimum of intervention by a technician. The apparatus includes a reservoir and a series of sample chambers attached to one end of the reservoir. A dialysis membrane that passes low-molecular-weight solutes, but not high-molecular-weight solutes, is placed between the reservoir and the first chamber. Another such membrane is placed between each chamber and the succeeding or preceding chamber. Access to each chamber can be gained through a screw-in plug in its side. Sliding gate valves between the precipitant and growth chambers could be used to start the growth process. The use of multiple chambers provides a gradation of nucleation and growth rates.

This work was done by Marc Lee Pusey for **Marshall Space Flight Center.** *To obtain a copy of the report, "Multiple Chamber Dialysis System for Protein Crystal Growth,"* ***write in 72*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-28967.



The Multiple-Chamber Dialysis Apparatus provides a gradation of nucleation and growth rates.

Coordinated Control of Mobile Robotic Manipulators

A computationally efficient scheme is suitable for real-time implementation.

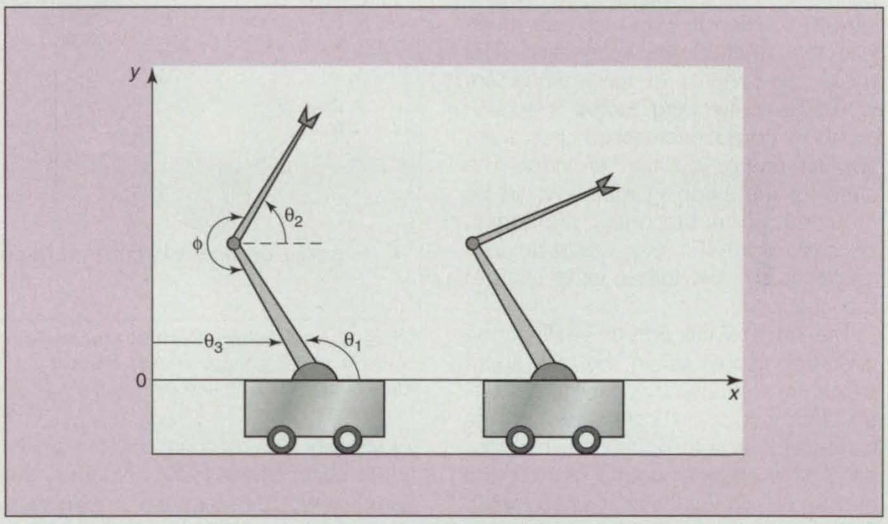
NASA's Jet Propulsion Laboratory, Pasadena, California

A computationally efficient scheme has been developed for on-line coordinated control of both manipulation and mobility of robots that include manipulator arms mounted on mobile bases. The scheme is applicable to a variety of mobile robotic manipulators, including robots that move along tracks (typically, painting and welding robots), robots mounted on gantries and capable of moving in all three dimensions, wheeled robots (see figure), and compound robots (consisting of robots mounted on other robots).

In the past, robots were typically mounted on stationary bases bolted to floors so that they could withstand the forces and torques applied to the bases when the robot arms carried payloads. However, there are significant advantages to placing robot arms on mobile bases. The mobility of a base extends the reach of the manipulator arm and increases the size of the robot workspace substantially at minimal cost. The additional movement of the base complicates the robot-control problem, but the availability of low-cost, high-performance computers makes it possible to achieve real-time control with computationally efficient algorithms like those of the present control scheme.

In some prior approaches taken in the development of control schemes, the additional degrees of freedom in the mobility of the base would have been regarded unfavorably because of the additional complexity that they introduce. In the present approach, the additional degrees of freedom are turned to advantage by using them to accomplish additional tasks specified by the user. Furthermore, the on-line nature of the present method is enhanced by the ability of the user to change the specifications of tasks during operation, as described below.

The theoretical basis of the present method is the configuration-control formalism, which was discussed in several prior articles in *NASA Tech Briefs*, including "Increasing the Dexterity of Redundant Robots" (NPO-17801), Vol. 14, No. 10 (October, 1990), page 88; "Redundant Robot Can Avoid Obstacles" (NPO-17852), Vol. 15, No. 10 (October, 1991), page 86; "Configuration-Control Scheme Copes With Singularities" (NPO-18556), Vol. 17, No. 2 (February, 1993), page 81; and "More Uses for Configuration Control of Robots" (NPO-18607/NPO-18608), Vol. 17, No. 10, (October, 1993), page 120. To recapitulate: A robot has n degrees of freedom. The basic task is to make the end effector (the hand at the tip of the manipulator arm) follow a prescribed trajectory in m-dimensional coordinates (where $m < n$). The $r = n-m$ redundant degrees of freedom are used simultaneously to perform an additional task.



A **Two-Link Robotic Manipulator Arm on a Wheeled Base** has redundant degrees of freedom that can be exploited via a control method based on the configuration-control formalism.

Additional tasks could include (but are not limited to) reaching around obstacles, avoiding collisions with objects in the workspace, maintaining one or more links of the manipulator arm in a desired pose, and/or optimizing the overall kinematics in both the redundant and nonredundant degrees of freedom to enhance overall manipulability. The additional task is mathematically modeled by a set of kinematic functions that, in effect, define the trajectory in the redundant degrees of freedom. These functions are specified by the user.

In the present method, the degrees of mobility are simply combined with the degrees of manipulation into one set that contains both the redundant and nonredundant degrees of freedom, and all degrees of freedom are treated on an equal footing according to the computationally efficient configuration-control formalism. The user can assign weighting factors to individual degrees of mobility or manipulation as well as to each task specification. The user can also change task specifications and weighting factors during operation. Thus, overall, the present method is characterized by conceptual simplicity, computational efficiency, and flexibility — all advantageous for on-line, real-time control.

This work was done by Homayoun Seraji of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 36*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office–JPL; (818) 354-5179. Refer to NPO-19109.

Tuneable Auxiliary Control Mechanisms for RUM Actuators

Scan amplitudes could be maximized and/or power consumption minimized under changing conditions.

Marshall Space Flight Center, Alabama

Tuneable auxiliary control mechanisms for rotating unbalanced-mass (RUM) actuators are used to maximize scan amplitudes and/or minimize power consumption during changing conditions. This type of mechanism is a more sophisticated version of the type of mechanism described in "Auxiliary Control Mechanisms for RUM Actuators" (MFS-28817), *NASA Tech Briefs*, Vol. 19, No. 8 (August, 1995), page 62.

To give meaning to an explanation of the tuneable version, it is necessary to repeat most of the description of the simpler version from the noted prior article. Figure 1 illustrates schematically a scientific instrument equipped with a pair of RUM actuators for oscillation about a single axis to produce a line scan, plus an auxiliary control mechanism that would establish and maintain a constant center-of-scan position and/or vary the center-of-scan at a rate much less than that of the scan itself. The basic components of this mechanism would be a stepping motor, a speed-reducing (torque-increasing) gear train, and an angular-position encoder. The stator of the stepping motor would be mounted on a stationary supporting structure, while the rotor would be connected to the low-torque input shaft of the gear train.

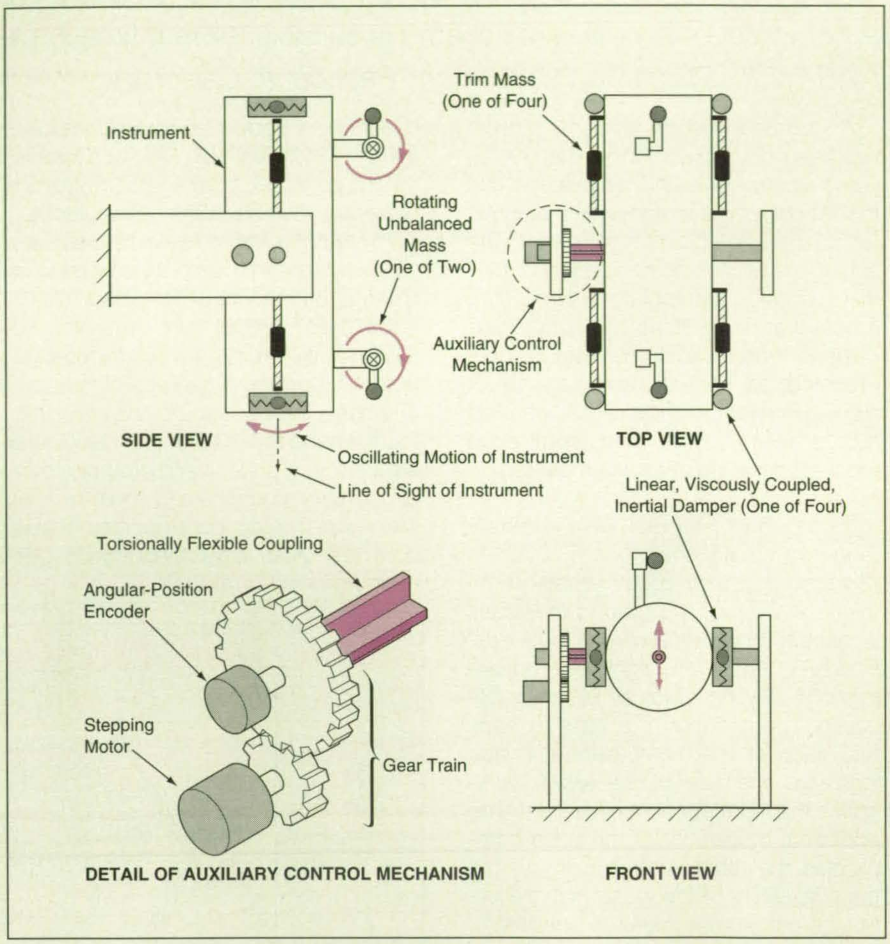


Figure 1. An **Auxiliary Control Mechanism** like this one would make it possible to design a relatively small, cheap, energy-efficient rotating unbalanced-mass actuator, but it could be adjusted to only a limited extent, if at all.

The high-torque output shaft of the gear train would lie on the axis about which the instrument was to be oscillated and would be connected to the instrument via a torsionally flexible coupling. The encoder would monitor the angular position of the high-torque shaft. Driven by a pair of RUM actuators, the instrument would oscillate torsionally, via the flexible coupling, about the angular position of the high-torque shaft. The holding torque of the stepping motor, amplified by the gear train, would suffice to prevent the slippage of the high-torque shaft out of the commanded center-of-scan position.

In many if not most cases, it would be preferable to choose the torsional stiffness of the flexible coupling so that the resonant frequency of torsional oscillation would equal the frequency of the scan produced by the RUM actuators. Adjustable trim masses could be added to provide for some limited tuning to resonance, and dampers could be added for stability. The resonance would amplify the effect of the RUM actuators (the dampers would reduce the amplification somewhat) so that the same scanning motion could be achieved with smaller unbalanced masses. With smaller unbalanced masses, the RUM actuators would consume less power: numerical examples from representative design cases suggest that RUM actuators equipped with auxiliary control mechanisms of this type would consume as little as 1/100 the power of scanning mechanisms based on gimbal torque actuators. This completes the explanation of the simpler previous version.

In the more sophisticated tuneable version, the torsional stiffness of the torsionally flexible coupling would be made adjustable on command. As shown in Figure 2, the torsional flexibility would be provided by a nominally radially oriented flexible blade. A rigid collar would attach the blade to the shaft connected to the scanned instrument and its RUM actuators. Movable rubber rollers would establish the off-axis contact point for transmission of torsion between the instrument shaft and the high-torque output shaft. The torsional stiffness would be increased or decreased by moving the rollers in or out, respectively. The rollers would be mounted on sleeves that could slide in radial grooves in a rigid frame attached to the high-torque output shaft. Each sleeve would be internally threaded to engage a radially oriented worm gear driven via a bevel gear by a stepping motor. Thus, the radial position of the collars and, with it, the torsional stiffness of the coupling, would be varied by use of the stepping motor.

Compumotor gets your motion control application started at the touch of a button.

Compumotor's Motion Architect® development software and 6000 Series controllers are a powerful combination.

With Motion Architect, a Microsoft® Windows™-based software development tool, you can generate commented setup code, edit and execute motion control programs, and create a custom operator test panel — all from an easy-to-access Windows™ environment.

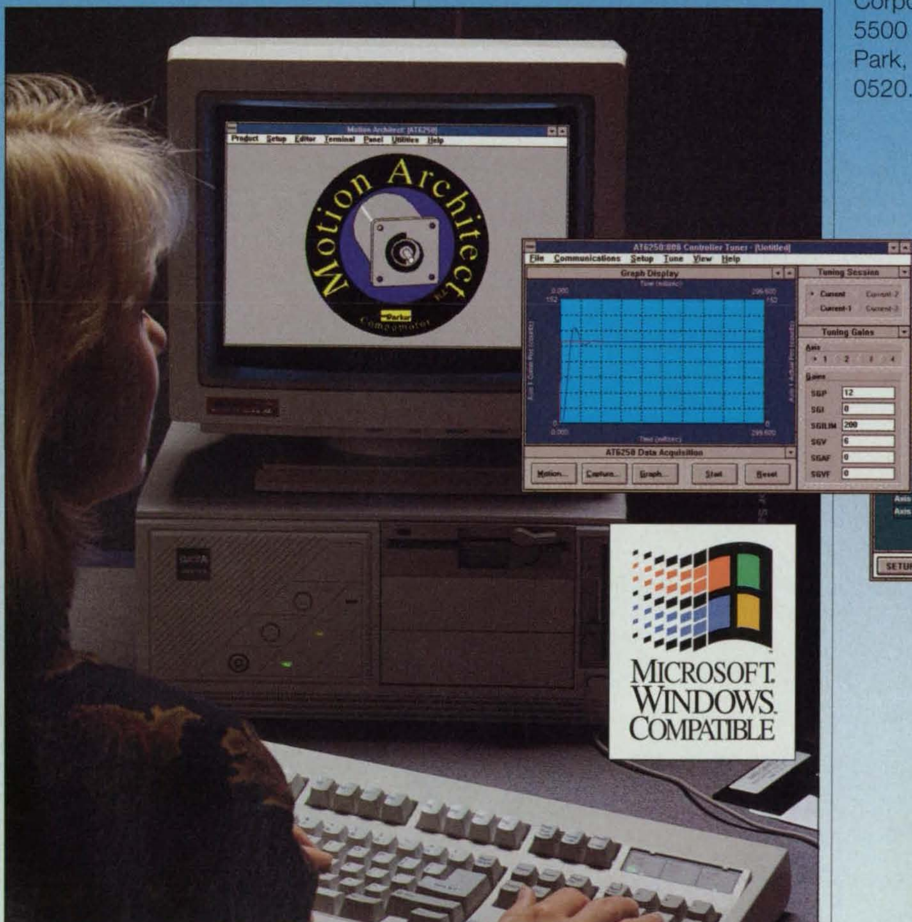
Solutions, not just components.

Combining Motion Architect with our 6000 Series controllers creates the best PC-AT® based or stand-alone motion control solutions available. Step and direction and analog output control for 1 to 4 axes with encoder feedback are available. The 6000 Series offers circular and linear interpolation, and ensures precise control of step motors or servo drives.

A worldwide network of Automated Technology Centers.

Motion Architect and Compumotor 6000 Series controllers are delivered and supported by an international network of factory-trained organizations specializing in the application of high technology automation equipment. Contact Compumotor for the Automation Technology Center nearest you.

For more detailed information on Motion Architect and the 6000 Series, just write Parker Hannifin Corporation, Compumotor Division, 5500 Business Park Drive, Rohnert Park, CA 94928. Or call 800-249-0520. Ask for dept. #1088



Motion Architect is standard with any 6000 Series controller to shorten project development time, simplify control, and add application versatility.

Worldclass Quality Products and Service

Parker
Motion & Control

For More Information Write In No. 620

The adjustability would provide enhanced tuning at any time; the mechanism could be tuned to a resonant or nonresonant condition as needed, even in real time during a scan. Thus, the same mechanism could be adjusted as needed to accommodate various instruments with widely different moments of inertia, adjusted to change the amplitudes of scans in real time, and/or adjusted in real time to respond to changes in the inertial properties of the scanned instrument.

A combination of a pair of RUM actuators and an auxiliary control mechanism more complicated than that shown in the figure could be used to produce a two-dimensional (e.g., elliptical or raster) scan. By making its torsional stiffnesses adjustable, one could adjust the amplitudes and other parameters of the scans in real time. For example, in the case of an elliptical scan, one could change the major and/or minor axis of the ellipse, compensate for the effect of gravitation on the major and/or minor axis to obtain a circular scan, or compensate for differences between moments of inertia about the two scan axes to obtain a circular scan.

This work was done by Michael E. Polites and Dean C. Alhorn of **Marshall Space Flight Center**. *For further information,* ***write in 98*** *on the TSP Request Card.*

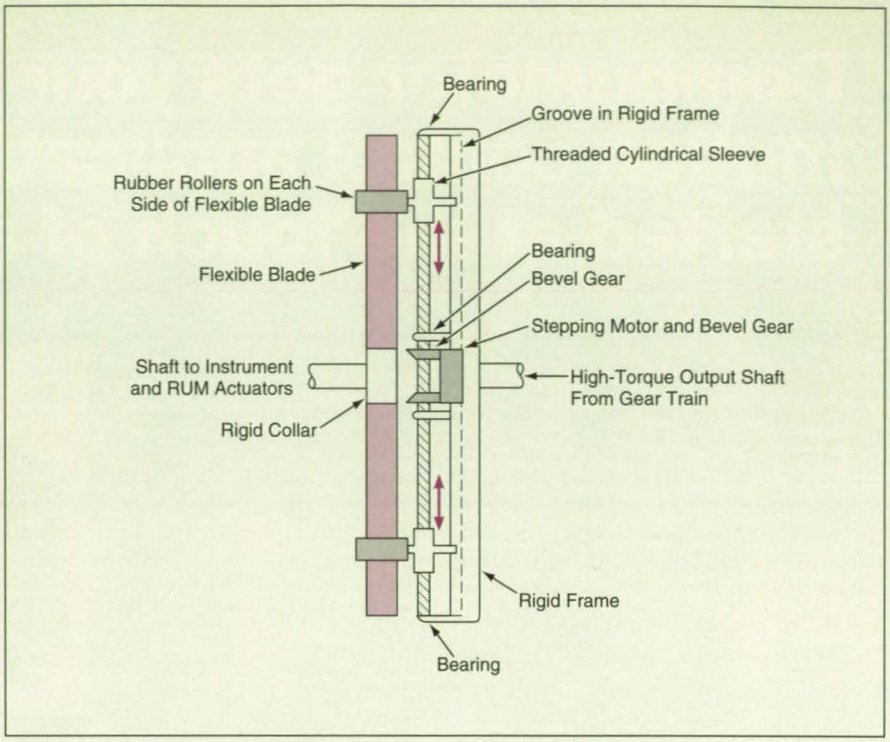


Figure 2. The **Torsionally Flexible Coupling** in a tuneable version of the auxiliary control mechanism of Figure 1 would be adjustable by use of a stepping-motor-driven worm-gear mechanism that would vary the bending length of a flexible blade.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-28930.

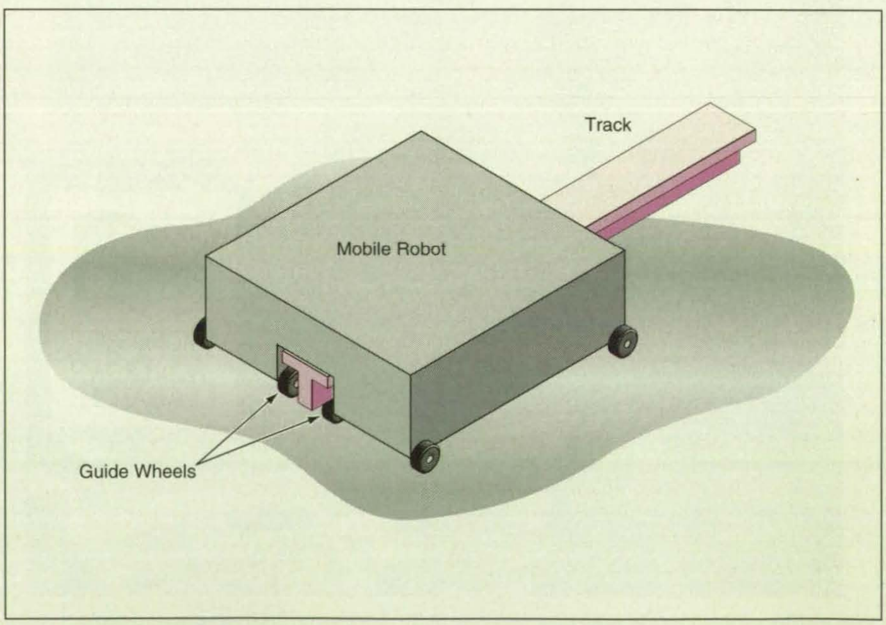
Modular Track System for Positioning Mobile Robots

A manipulator could reach desired positions more quickly and easily.

NASA's Jet Propulsion Laboratory, Pasadena, California

A conceptual system for positioning mobile robotic manipulators on a large main structure would include modular tracks and ancillary structures that could be assembled easily along with the main structure. The system, called the "tracked robotic location system" (TROLS), was originally intended for application to platforms in outer space, but the TROLS concept might also prove useful on Earth; for example, to position robots in factories and warehouses.

The design of the TROLS would inherently solve some of the problems commonly encountered in positioning and orienting mobile robots. The surfaces of the main structure would be covered with the tracks, enabling the robots to reach all areas of interest. The contact between a robot and its tracks would automatically enforce the correct orientation. The main structure or the ancillary structures adjacent to the



A **T-Cross-Section Rail** would keep a mobile robot on its track. Bar codes would mark locations along the track.

tracks would be marked with bar codes. Each robot would be equipped with bar-code-recognizing circuitry so that it could quickly find its way to its assigned location.

The tracks of the TROLS could be in the form of rails (see figure), grooves, or channels. The tracks would be built with standard dimensions and spacing so any module could be aligned with any adjacent module. The tracks would be located to enable robots to reach any object with which robots were required to interact.

This work was done by Jeff Miller of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 70*** *on the TSP Request Card.* *NPO-19387*

Mechanism for Adjustment of Commutation of Brushless Motor

The adjustment can be performed while the motor is running.

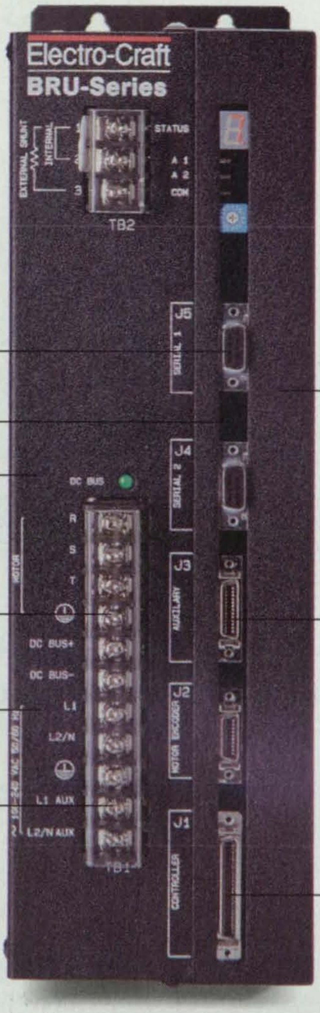
Marshall Space Flight Center, Alabama

A mechanism enables the adjustment of the angular position of a set of Hall-effect devices that sense the instantaneous shaft angle of a brushless dc motor. The outputs of the sensors are fed to commutation circuitry. Measurement of the shaft angle is essential for commutation; that is, the application of voltage to the stator windings must be synchronized with the shaft angle. To obtain the correct angle measurement for commutation, the Hall-effect angle sensors must be positioned at the proper reference angle.

The Hall-effect angle sensors are mounted on an annular board called, appropriately, the "commutation board." The commutation board is mounted on one end of the motor housing. Part of the rotor and shaft pass through the central hole of the commutation board. Heretofore, the angular position of the sensors was adjusted by turning off the motor, removing the end cap (which covers the commutation board), loosening the mounting screws that hold the commutation board, and manually rotating the commutation board by a small amount. The cap was then reinstalled and the motor was turned on, and the current drawn by the motor was measured. This procedure was repeated until an approximately minimum current reading was obtained. (A minimum current reading signifies maximum operating efficiency.)

The present mechanism (see figure) accelerates the adjustment procedure and makes it possible to obtain a more accurate indication of the minimum-current position because it provides for adjustment while the motor is running. The commutation board is held on the end of the housing by three mounting screws that are fitted with close tolerance to short circumferential slots in the

BRU SERIES

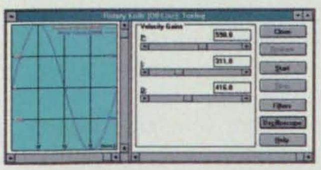


- *BRU Master, Windows™-based software*
- *Large scale integration with custom ASICs for performance and reliability*
- *UL, cUL listed and CE marked*
- *Drive sinusoidal AC brushless or induction motors*
- *10, 20, 30, 75 Peak Amps (150 Amp Available in 1996)*
- *Built-in power supplies - no external source required except AC line*

- *Advanced multi-processor design for leading edge 200 micro-second velocity loop update rate, digital current, velocity and position loops, and advanced low speed control algorithm*
- *4 dedicated I/O plus 8 user programmable optically isolated digital inputs and outputs (sourcing/active high)*
- *Choice of command source:*
  - *+/- 10V analog input*
  - *step/direction input (also step up/step down)*
  - *auxiliary master encoder input*
  - *8 preset speeds/torques selected via 3 digital input lines*
  - *RS232/485 commands*

BRUTALLY VERSATILE.

Introducing the Electro-Craft® BRU-Series Advantage Line–a feature-rich family of brutally versatile drives you can depend on. No matter what application. No matter what industry. No matter what controller.



The BRU-Series was the first to integrate brushless servo and vector drive technology into a single drive. So whether you need an analog input velocity servo, a variable speed drive, a stepper drive replacement, or a master encoder follower–the BRU-Series' savage versatility makes it the original feature creature.

Standardizing on BRU-Series drives means less inventory and fewer spare parts on your shelves. And that means fewer maintenance headaches, less downtime, and a lower life cycle cost for all your drives. And unlike other drives, it doesn't take brute force to setup the BRU-Series. The easy-to-use, Windows™-based interface guides you through setup and tuning in a snap.

To learn how the BRU-Series of universal drives can tame your application, call us today at **1-800-328-3983**. Reliance Motion Control. **THE RIGHT COMPANY. THE RIGHT SOLUTION.**

Electro-Craft® SERVO SYSTEMS

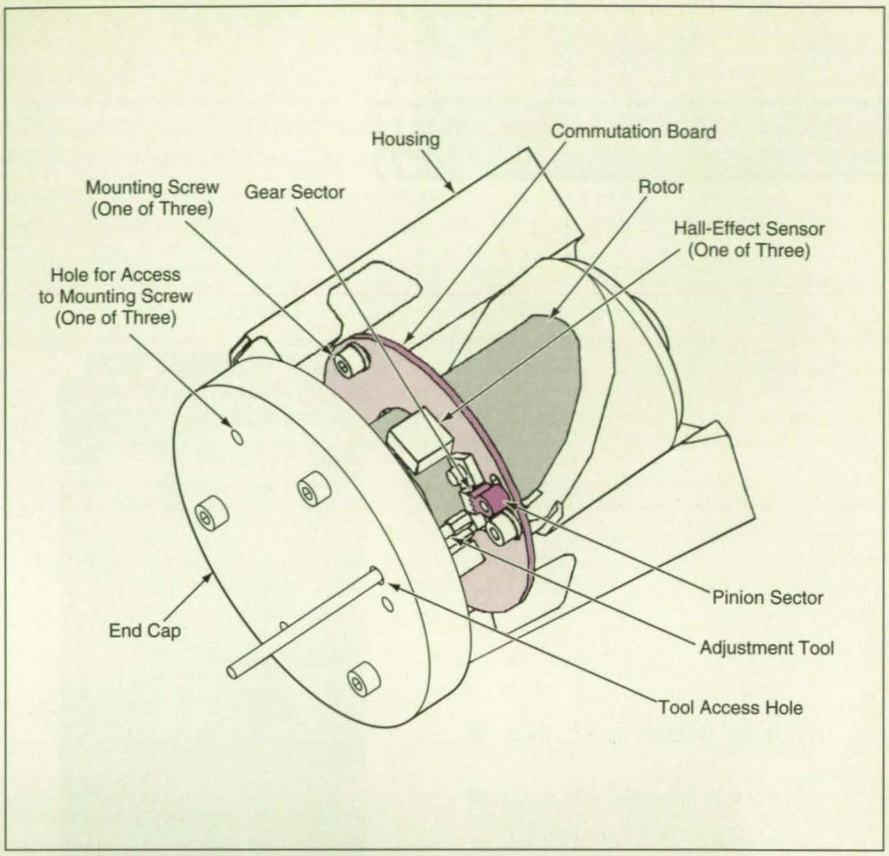
For More Information Write In No. 622

board. Preload springs under the heads of the mounting screws prevent inadvertent rotation of the commutation board when the screws are loosened for an adjustment. A gear sector is mounted at a location on the periphery of the commutation board; this gear sector engages a pinion sector that turns on a pin attached to the housing. The pinion and gear sectors feature a zero-backlash design.

A socket on the pinion receives an adjusting tool. To perform an adjustment, one inserts the tool in the socket via an access hole in the end cap. The tool is turned to rotate the pinion. By virtue of the gear ratio, this effects a fine angular adjustment of the commutation board. Once the adjustment yields a minimum current reading, the preload springs hold the board until the mounting screws are retightened.

This work was done by Richard E. Schaefer of United Technologies Hamilton Standard for **Marshall Space Flight Center.** *For further information,* ***write in 38*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-28958.



Holes in the End Cap provide access to the adjustment mechanism and to the mounting screws that hold the commutation board on the end of the housing.

Unified Approach to Control of Motions of Mobile Robots

An updated configuration-control scheme incorporates a distinction between holonomic and nonholonomic constraints.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved computationally efficient scheme has been developed for on-line coordinated control of both manipulation and mobility of robots that include manipulator arms mounted on mobile bases. The present scheme is similar to the one described above in "Coordinated Control of Mobile Robotic Manipulators" (page 1b). Both schemes are based on the configuration-control formalism. The major difference between the two schemes is that unlike the previous one, the present one incorporates an explicit distinction between holonomic and nonholonomic constraints (see figure). Both schemes are characterized by computational efficiency and flexibility, which are advantageous for on-line, real-time control.

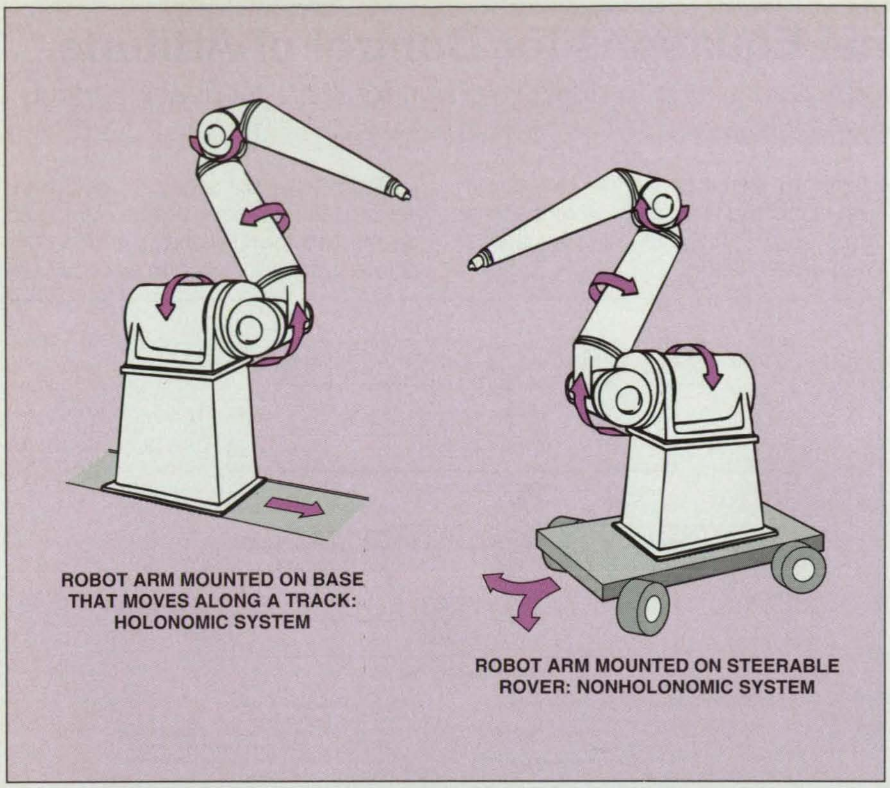
In addition to the article cited above, several other prior articles in *NASA Tech Briefs* have discussed aspects of the configuration-control formalism. These include "Increasing the Dexterity of Redundant Robots" (NPO-17801), Vol. 14, No. 10 (October, 1990), page 88; "Redundant Robot Can Avoid Obstacles" (NPO-17852, Vol. 15, No. 10 (October, 1991), page 86; "Configuration-Control Scheme Copes with Singularities" (NPO-18556), Vol 17, No. 2 (February, 1993), page 81; and "More Uses for Configuration Control of Robots" (NPO-18607/NPO-18608), Vol. 17, No. 10 (October, 1993), page 120. To recapitulate: A robot has n degrees of freedom. The basic task is to make the end effector (the hand at the tip of the manipulator arm) follow a prescribed trajectory in m-dimensional coordinates (where $m<n$). The $r=n-m$ redundant degrees of freedom are used simultaneously to perform an additional task.

The additional task can be specified by the user and can include (but is not limited to) reaching around obstacles, avoiding collisions with objects in the workspace, maintaining one or more links of the manipulator arm in a desired pose, and/or optimizing the overall kinematics in both the redundant and nonredundant degrees of freedom to enhance overall manipulability. The additional task is mathematically modeled by a set of kinematic functions that, in effect, define the trajectory in the redundant degrees of freedom. The user can assign weighting factors to individual degrees of mobility or manipulation as well as to each task specification. The user can also change task specifications and weighting factors during operation.

In the present scheme, the degrees of mobility and the degrees of manipulation are treated within a common theoretically framework; to put it in slightly different terms, the mobile base and the manipulator are treated as closely

interacting subsystems of the overall robotic system, rather than as two separate entities. Within this framework, the kinematic constraints upon the manipulator subsystem are holonomic, whereas those on the mobile base can be nonholonomic, depending on the type of mobile base. All degrees of freedom are treated on an equal footing according to the computationally efficient configuration-control formalism. The nonholonomic kinematic constraints (if any) fit naturally into the configuration-control formalism: the nonholonomic kinematic constraints, the desired motion of the end effector, and the additional task specified by the user are combined to form a set of augmented tasks. These tasks are then accomplished in a coordinated manner by use of the configuration-control equations to determine the motion in each mobility and manipulation degree of freedom.

This work was done by Homayoun Seraji of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 61*** *on the TSP Request Card. NPO-19508*



The **Constraints Upon the Motion of a Mobile Base** that supports a robot arm can be either holonomic (e.g., the kinematic constraints upon a mobile base that moves along a track) or nonholonomic (e.g., the kinematic constraints upon a mobile base with wheels like that of an ordinary highway vehicle).

Inversion of Dynamical Equations for Control of Attitude

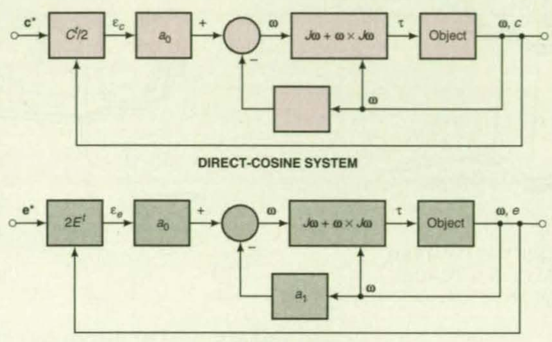
Quaternion and direction-cosine formulations lead to direct inversion for linear feedback control.

Ames Research Center, Moffett Field, California

A method of inverting the nonlinear equations of the rotational dynamics of a rigid body could be used to design feedback control of the orientation of the body. The method is applicable to both direction-cosine and quaternion formulations, which are suitable for large-angle maneuvers. (These formulations are preferable to a Euler-angle formulation, which lends itself readily to inversion, but is not suitable for large-angle maneuvers.) Exploiting some apparently little-known properties of the direction cosine and quaternion formulations, the method leads to equations for a model-follower control system that exhibits exactly linear attitude-error dynamics.

Taking parallel approaches in both the direction-cosine and quaternion formulations, the method involves the simplification of the inversion of the equations for the angular accelerations as functions of the applied torques. The simplification is effected by transformations of coordinates that make it possible to express the angular velocity and angular acceleration in terms of the direction-cosine or quaternion elements and their derivatives with respect to time, the transformations being such that the resulting equations of state are linear.

Figure 1 depicts schematically the linearized attitude-control systems based on the two formulations. The direction-cosine system is limited to following roll-



Notes:

1. $\mathbf{c}^*$ = commanded orientation expressed in direction cosines.
2. C' = a transformation matrix in the direction-cosine kinematics.
3. ε_c = the attitude error expressed in direction cosines.
4. $\mathbf{c}$ = actual orientation expressed in direction cosines.
5. a_0 = a control gain that varies with time in such a way as to yield linear response.
6. J = inertial matrix of the body.
7. ω = angular velocity.
8. τ = control torque.
9. a_1 = a control gain that is adjusted to yield acceptable transient performance.
10. $\mathbf{e}^*$ = commanded orientation expressed in quaternions.
11. E' = a transformation matrix in the quaternion kinematics.
12. ε_e = the attitude error expressed in quaternions.

Figure 1. **Linearized Attitude-Control Systems** are synthesized by use of coordinate transformations that simplify the inversion of the basic equations of motion of a rigid body.

angle commands In the range of +180°, while the quaternion system can follow commands in the range of +360°.

The error amplitude in the quaternion formulation is a maximum for commands of +180°, for which the error amplitude in the direction-cosine formulation is zero. Therefore, the quaternion system should be more robust in responding to large roll-angle commands.

This work was done by Ralph Bach and Russell Paielli of **Ames Research Center**. *For further information,* ***write in 23*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-12769.

Adaptive Force Control for Compliant Motion of a Robot

Performance is expected to be stable and uniform despite gross variations in environmental stiffnesses.

NASA's Jet Propulsion Laboratory, Pasadena, California

Two adaptive control schemes offer robust solutions to the problem of stable control of the forces of contact between a robotic manipulator and objects in its environment. These schemes were developed within the compliant-motion control framework, as were a number of other robot-control schemes reported previously in *NASA Tech Briefs*.

A control scheme that ensures stable and robust operation of a robotic manipulator in contact with objects in its environment is a basic requirement for the successful execution of many robotic tasks. The control problem is especially challenging in an environment in which the stiffnesses of objects with which the end effector of the robot can make contact ("environmental stiffnesses" for short) are unknown and/or subject to change. The present control schemes provide for automatic tuning of the force controller of the robot to compensate for unknown and/or changing environmental stiffnesses in order to yield stable, uniform, and acceptable performance.

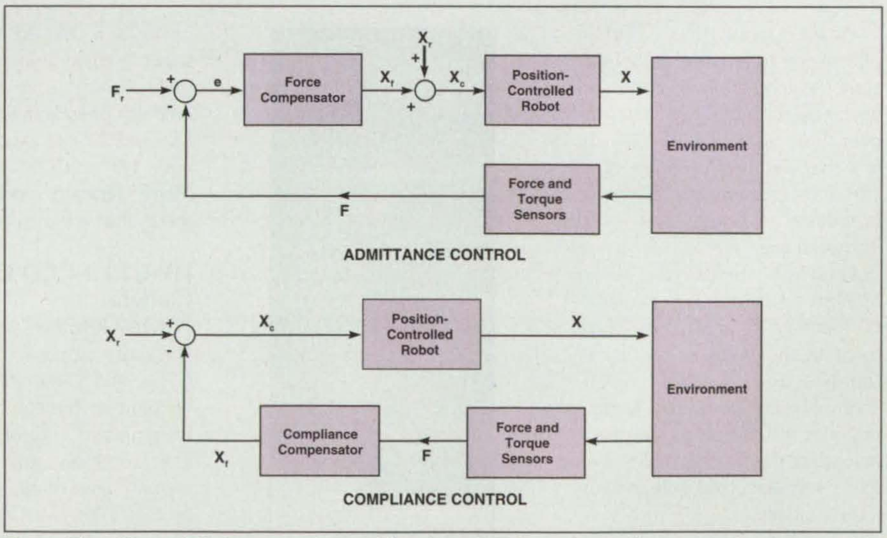
The two control schemes (see figure) are called "adaptive admittance control" and "adaptive compliance control." Both schemes involve the use of force-and torque sensors that indicate contact forces, **F**. The force-and-torque sensors can be replaced with proximity sensors, the outputs of which can be processed into virtual-contact-force signals, as though the end effector made contact with a nearby object via a spring. These virtual-contact-force signals are useful in preventing collisions with objects, following contours, and maintaining desired standoff distances.

Admittance control is an explicit force-control scheme in which a force set point, $\mathbf{F}_r$, is specified by the user and is tracked by a force compensator. This scheme is based partly on the concept of mechanical admittance, which relates the contact force to the resulting velocity perturbation. The end effector of the robot is commanded to deviate from its commanded position $\mathbf{X}_r$ by the amount $\mathbf{X}_f$ and to track the modified commanded trajectory $\mathbf{X}_c$. Two adaptive proportional-plus-integral-plus-derivative (PID) and proportional-plus-integral (PI) force compensators have been developed thus far and found to ensure robust tracking.

Compliance control is an implicit force-control scheme: this scheme establishes robot/environment interaction dynamics specified by the user in terms of a contact force as function of the difference between the actual position **X** and the desired position, $\mathbf{X}_r$, of the end effector. Two adaptive lag-plus-feedforward compliance compensators have been developed. The compliance compensators and the PI force compensator do not require information on the rate of change of force. Both the admittance and compliance control schemes included adaptation laws that constantly adjust the compensator gains to drive tracking errors toward zero; this is the feature that helps to ensure stable and uniform performance despite large variations in environmental stiffnesses.

These schemes performed well when tested in computational simulations in which they were used to control a seven-degree-of-freedom robot arm in executing contact tasks. The admittance scheme offers (1) the advantage of robust tracking of force set points and rejection of constant disturbances and (2) the disadvantage of requiring switching between reference motion command trajectories for unconstrained tasks and force-set-point command trajectories for constrained tasks and possible poor responses during transitions between them. The compliance scheme involves the use of reference motion commands in tasks of both types, so that it does not require switching of commands and therefore affords generally good responses during transitions. However, the compliance scheme offers the disadvantage of possibly less robust tracking of force commands and rejection of force disturbances. Therefore, the choice between admittance or compliance control is dictated by the requirements of the application at hand.

This work was done by Homayoun Seraji of Caltech for **NASA's Jet Propulsion Laboratory**. *For more information,* ***write in 59*** *on the TSP Request Card. NPO-19507*

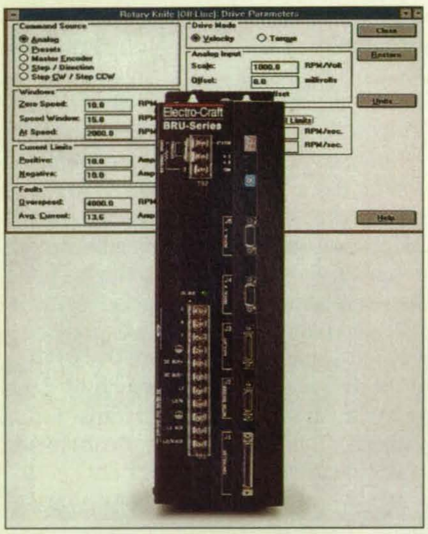


These **Two Control Schemes**, along with adaptation laws that adjust control gains, provide robust, stable control of a robot operating in the presence of unknown and/or changing environmental stiffnesses.

Motion Control Industry Leaders

RELIANCE MOTION CONTROL

Reliance Motion Control in Eden Prairie, MN, introduces universal brushless servo/vector drives as its latest addition to the Electro-Craft servo system family.



The BRU-Series Advantage Line is a feature-rich, high-performance family of versatile drives that can cover a wide range of applications--anything from an analog input velocity servo or a variable speed drive, all the way to a stepper drive replacement or a master encoder follower.

It's also the one drive for just about any type of controller. With the click of a mouse, the Advantage Line can be configured for almost any controller. With its high-resolution, 16-bit A/D converter, your drive is ready for precise control as an analog input drive for high-performance servo applications. Click again and it can accept standard digital step and direction inputs from an indexer, giving you a high-power, high-performance alternative to a stepper drive without having to replace or reprogram your controller. And with its built-in, pre-set speeds and digital I/O functions, you can also use the BRU-Series to control an induction motor as a variable speed drive. Just by selecting a motor, the new BRU-Series Advantage Line drive automatically configures itself as either an AC brushless servo drive or a high-performance vector drive. The BRU-Series was the first to integrate brushless servo and vector drive technology into a single drive.

Standardizing on BRU-Series drives for all your applications means greater flexibility and less wear and tear on your most important asset–your people. With BRU-Series on your machines, you'll have less inventory on your shelves, fewer spare parts to track, fewer piles of manuals to read through, and less risk of not having the right spare part when you need it.

For more information about the Electro-Craft BRU-Series family, call 800-328-3983.

For More Information Write In No. 640

HITACHI DENSHI AMERICA LTD.

Providing Video Solutions

Hitachi Denshi America Ltd., a part of the international industry giant Hitachi Limited, has been operating in the United States for over thirty years. Hitachi Denshi is a manufacturer of video cameras and accessory equipment for broadcast, professional and industrial use.

Hitachi's Industrial Video Systems Division has concentrated much of its product development in the fields of medicine, robotics and machine vision. Today, Hitachi Denshi is a leading provider of both color and black and white cameras to OEMs, system integrators, and end users in these markets.

KPM Series B&W Cameras

One of Hitachi's most popular cameras is the KP-M1, a very small, rugged unit using a 2/3" CCD sensor. This camera has recently been joined by the KP-M2 and KP-M3 which use 1/2" and 1/3" CCDs, respectively. Many standard modifications of these units are available.

HV-C20 3-CCD Color Camera

While less than a year old, the HV-C20 camera, using 1/2" CCDs and C-mount optics, has become a hot product in the imaging and microscopy market. The extremely small camera is digitally controlled, integrates up to 60 fields, provides field-on-demand with external triggering, and can be purchased with either co-site sampling or spatial offset.

New Full-Line Catalog

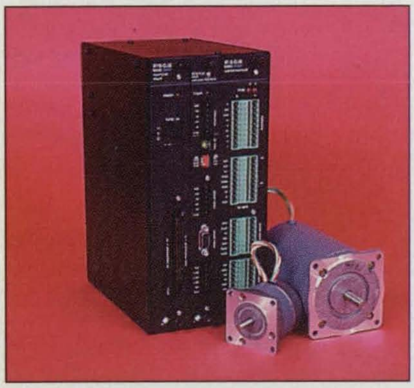
To receive information on Hitachi Denshi's broad line of industrial video products, fax your request to 516-496-3718, or call your regional office: **New York:** 516-921-7200; **Atlanta:** 770-242-3636; **Chicago:** 708-250-8050; **Dallas:** 817-488-4528; **Los Angeles:** 310-328-6116.

For More Information Write In No. 639

SUPERIOR ELECTRIC

Since 1962, when Superior Electric originated AC synchronous and DC stepping motors, the company has been ranked as one of the leading suppliers of motion control products worldwide.

CONTROLLERS–The most recent innovative product in its prestigious SLO-SYN® line is the MX2000 programmable, multi-axis motion controller. This 32-bit controller can handle 2 to 8 axes of servo or stepper motors utilizing the latest available hardware, including digital signal processing (DSP) and custom-programmed, application-specific integrated circuits (ASICs). Three modular enclosure configurations permit the flexibility of installing a fully configured, 2-axis controller up to one that is expandable to 8 axes in a 19-inch rack frame. Features are: stepper and servo interface, multi-tasking capability up to seven concurrent tasks, up to 352 inputs and outputs separately scanned for control, advanced linear and circular interpolation plus splining, powerful BASIC language programming, full math functions of trig, logs, square root and Boolean expressions. Has built-in power supplies for 90 to 265 VAC operation. A flow chart, object-oriented programming language is available.



Superior Electric is so convinced of the MX2000 controller's exceptional capabilities, that it offers a "no-hassle" performance guarantee of the return of the cost if the controller does not perform satisfactorily when the installation is made in compliance with company field sales or application engineering recommendations.

Superior Electric's extensive line of motion controllers also includes modular and packaged step motor drives, programmable indexers and oscillator/analog speed followers.

DC STEPPER MOTORS–Brushless, permanent magnet motors that have full step increment of 1.8°. Can also operate in increments of 0.9° to 0.0144°. Up to 3-1/2 HP available with appropriate drives. Wide range of torque ratings.

AC SYNCHRONOUS MOTORS–Have extremely rapid start, stop and reverse characteristics (within 25 milliseconds or 5° typical); slow basic shaft speeds of 72 or 200 rpm at 60 Hz. Also available as gearmotors. Can stall without damage.

SERVO SYSTEMS–Consist of **servo motors** with torque ratings from 7.44 to 708 in-lb continuous; UL-listed, resolver-based **servo amplifiers** with 6 to 110 A peak; UL-listed **servo power supplies** with direct line voltage input, shunt overload protection, multiple amplifier operation. Amplifiers packaged with MX2000-compatible controls available.

For more information, call 800-787-3532 today. We're ISO 9002 quality certified.

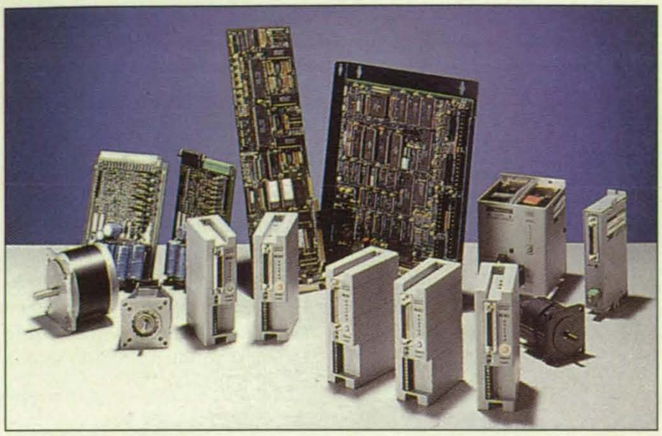
For More Information Write In No. 644

For More Information Write In No. 637

PARKER HANNIFIN CORP., COMPUMOTOR DIVISION

Compumotor: A Pioneer in Microstepping and Servo Motor Technologies

Incorporated in 1979, Compumotor earned its reputation for innovation by pioneering microstepping drive techniques to improve the smoothness and resolution of step motor control systems. Compumotor's innovative leadership has continued to produce a complete line of stepper motor and servo drive systems, computer bus-based and standalone controllers, and extensive applications software. Parker Hannifin's acquisition of Compumotor in 1986 fostered breakthroughs in servo technology, followed by AC brushless drives, DSP servo controller techniques, and smart drive controller combinations. Today, after a decade of innovation, Compumotor is among the largest service-oriented and most technologically advanced suppliers of electronic motion controls in the world.



Compumotor's OEM Series is a complete line of controllers, servo systems, and open-loop stepper systems designed especially for high-volume applications.

The Complete Solution

We provide more than just the products necessary for today's demanding automation requirements. An accessible network of knowledgeable worldwide support resources accompanies every product. To maintain our leadership position in the electronic motion control industry as a complete supplier of electromechanical solutions, it is mandatory that we continue to identify, invest in, and develop those technologies, products, services, and processes that will always keep our products ahead of the competition.

Custom Service and Custom Products

It is impossible to anticipate every need of every individual (and unique) customer. After evaluating our extensive line of products, you may decide that a customized version of a standard product is required. A custom product can be anything from a software modification to integrating our products into larger systems. Compumotor is prepared to quickly respond and adapt to your specific requirements.

The Right Choice

Compumotor's distinguished product excellence and experience in the electronic motion control industry is as far-reaching as our global support network. Selecting a Compumotor product is much more than a decision for today–it is an investment in your future.

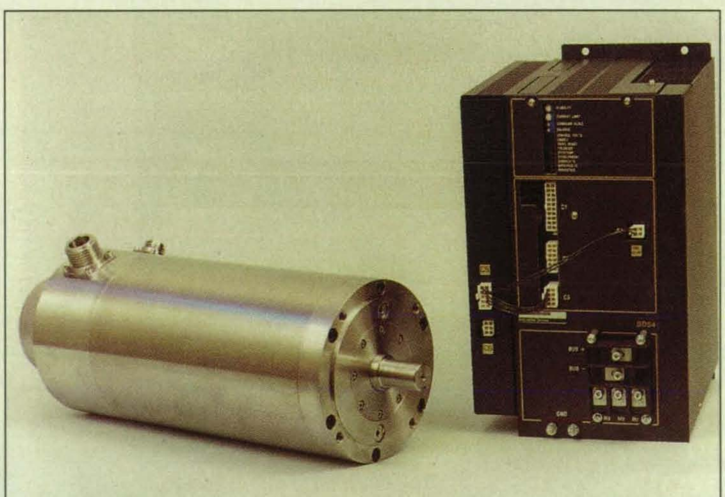
For more information, write to: Parker Hannifin Corp., Compumotor Division, 5500 Business Park Drive, Rohnert Park, CA 94928.

For More Information Write In No. 643

KOLLMORGEN MOTION TECHNOLOGIES GROUP, INLAND MOTOR

New Products for Underwater Applications

Kollmorgen Motion Technologies Group designs motion control systems specifically for underwater and submersible applications. Our Goldline submersible DC brushless motor features stainless steel and aluminum nickel bronze housings or an anodized aluminum housing. All shafts are stainless steel and the shaft seal is externally serviceable. Otherwise, all joints are O-ring sealed and the standard connectors used are by Sea Conn. These motors are pressure-compensated to 20,000 feet and designed to withstand severe shock and extreme environments. Goldline submersible systems are fully tooled for volume production and are a cost-effective solution to your motion control problem. Motors range in size from 3" to 8" in diameter and range from 1 to 40 hp.



The BDS4S series of motor controllers operates in conjunction with a three-phase permanent magnet brushless DC motor, such as the Goldline submersible series. The S series controller is essentially the same as the standard BDS4 controller, except it can operate from a single DC power supply. The controller produces three sinusoidal outputs to the motor. Commutation and velocity feedback are provided by a brushless resolver within the motor.

Kollmorgen has a long history in submersible products. You will find our motion control products on U.S. military submarine and most tourist class subs as well. We have been a part of many scientific underwater vehicles such as Jason Jr., Seaeye Marine 600 MkII, and SD-1. Other electronic motor controller systems also are available. A complete data sheet is available on request.

For more information, contact Kollmorgen Motion Technologies Group, Inland Motor, 501 First Street, Radford, VA 24141; Tel: (703) 639-9045; Fax: (703) 731-4193.

For More Information Write In No. 641

NOOK INDUSTRIES, INC.

For over 25 years, Nook Industries, Cleveland, OH, has been a major source of linear motion power transmission components. Nook Industries designs, manufactures and distributes a broad range of competitively-priced, energy-efficient linear motion components, accessories and systems serving the commercial and military markets and industrial equipment manufacturers to provide low-cost linear power transmission and guidance.

ActionJac™ Electric Cylinder Actuators were developed to fill the need for an enclosed, electric-powered, telescoping cylinder actuator. PowerTrac™ Precision Ball Screws are used to boost mechanical efficiency and increase positioning accuracy. Improved mechanical efficiency reduces drive motor torque requirements and hence, required motor size, by as much as one-third when compared to a similar actuator built around a screw with conventional threads. The electric cylinder is a clean, compact alternative to hydraulic systems and is capable of precise positioning.

Three model series of ActionJac Electric Cylinder Actuators are currently available from Nook Industries with dynamic load capacities from 500 to 40,000 lbs. and a broad range of travel rates: the DD Series (single reduction), the DDL Series (single reduction with torque limiter), and the RAD Series (double reduction). All electric cylinders are supplied with the following options: standard male clevis mounts; cylinder bearing supports; integral motors; hard, chrome-plated inner tubes; and PowerAc™ Acme Screws or PowerTrac Ball Screws for long, predictable life. Accessories include rod-type or rotary limit switches. An In-Line Encoder may be factory-installed for some electric cylinders in the DD Series.

The ActionJac Electric Cylinder Actuator is supplied with a standard 230/460 VAC 3-phase motor or optional 120 VAC, single-phase motor. All motors have spring-applied integral brakes to help prevent back-driving when

the motor power is turned off. The motor is installed with standard motor mounts. Standard strokes up to 120" are available, depending on the cylinder size.

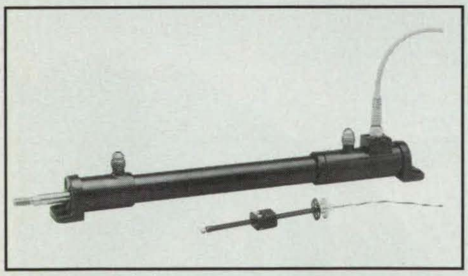
Electric cylinder actuators are widely used in industrial and manufacturing applications and in steel and paper mills when roll-type processing equipment needs periodic adjustment. Electric cylinder actuators also raise and position aircraft maintenance platforms and stages. Commercial and military satellite antenna manufacturers are using electric cylinder actuators for precise positioning of large, dish-type antennas.

When compared to air and hydraulic units, in addition to providing higher accuracy, they offer improved energy efficiency and longer life, frequently at a lower cost. Electric cylinder actuators also allow cleaner operation and easier synchronization in multiple actuator systems.

To receive a free design guide for ActionJac Electric Cylinder Actuators, call our Engineering "Hotline" at 800-321-7800 or Fax: 216-464-4669. (ActionJac™, PowerAc™ and PowerTrac™ are registered trademarks of Nook Industries, Inc., 23200 Commerce Park Road, Cleveland, OH 44122-5869.)

For More Information Write In No. 645

OILDYNE INTRODUCES TWO NEW INNOVATIVE PRODUCTS



½" Bore Smart Cylinder

½" Bore Hydraulic Smart Cylinder

Oildyne EMC Group has designed one of the smallest Smart Cylinders ever available. The cylinder is a remarkably small ½" bore, complete with an internal position feedback transducer that provides for infinite positioning capability. This is a perfect package for those applications where space is a premium but positioning and hydraulic forces are required. The cylinder features a maximum 9" stroke length and pressures up to 2500 psi. There is a miniature 3-pin quick disconnect electrical connector for connection to a PLC or other electronic motion controller.

Miniature Valve Pad Smart Cylinder

Oildyne has also developed a miniature Smart Cylinder featuring an integral hydraulic proportional valve pad and valve. Now, for the first time, it is possible to have a 1" bore hydraulic smart cylinder and mini hydraulic proportional valve as one complete integrated package. This provides a totally unique product for those applications where space is at a premium but hydraulic forces and positioning are a requirement.

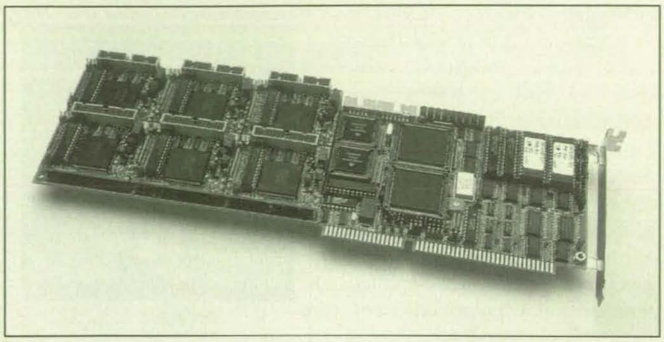
1" Bore with Mini NG3 Valve

These products are a part of a uniquely designed linear resistor position transducer family that allows for internal installation in cylinders as small as ½" bore. They feature a right angle exit for an electrical connection that provides an advantage not found in most position transducers. The design also has the advantage of being manufactured in any length desired rather than only in 1", 2", or 6" increments. For hydraulic or pneumatic applications the LRT/ MLRT family provides the designer the opportunity for the smallest profile, infinite resolution, and linearity from .1% to 1% of stroke, depending on the model.

For More Information Write In No. 646

PRECISION MICROCONTROL CORPORATION

Motion Control for Robotics and Machine Automation



Precision MicroControl revolutionized the motion control industry with the DCX Modular Motion and I/O Control System. The DCX system is based on the concept of Distributed Process Control, where the intelligence functions are distributed among components. The DCX system uses a Plug-and-Play building-block approach to motion control. The result is a flexible, open architecture platform, allowing each controller to be individually configured to match the application. The distributed processing design allows motion and I/O functions to be added without performance degradation.

The DCX system includes five Motion Control motherboard models to choose from supporting PC/ISA bus, VME bus, and standalone applications. With more than 13 intelligent function modules, the DCX modular architecture offers the most flexible, plug-and-play motion control environment available today.

If application requirements change, simply add or subtract DCX modules. Unlike other systems, there is no need to return the controller to the factory to be reconfigured.

PMC's Software is FREE

PMC is dedicated to producing state-of-the-art motion and I/O control systems. We believe that hardware and software tools are best packaged together to insure compatibility and avoid any hidden costs. Software included free of charge includes: Windows API (for all Windows programming environments), Windows Servo Tuning Utility, DOS API, DOS High-Level Language Libraries (C, BASIC, and Pascal), and a PC/ISA-based, 3-D CNC application program.

Motion Control Programming

All PMC motion controllers offer the flexibility of two different programming environments. We offer a simple and intuitive Motion Control Command Language (MCCL) where sophisticated Motion and I/O functions can easily be implemented by users without previous programming experience. For the experienced programmer, PMC's powerful Motion Control Application Program ming Interface (MCAPI) provides direct support for programming from popular, high-level programming languages. In Windows or DOS environments, the MCAPI utilizes the PMC Direct Binary Interface to support high-speed bus communication.

For more information, contact PMC Corp., 2075-N Corte del Nogal, Carlsbad, CA 92009; Tel: 619-930-0101; Fax: 619-930-0222; E-mail: (for product information) pmcinfo@pmccorp.com; (for technical support) motion@pmccorp.com.

For More Information Write In No. 647

Books & Reports

These reports, studies, and handbooks are available from NASA as Technical Support Packages (TSPs) when a Request Card number is cited; otherwise they are available from the NASA Center for Aerospace Information.

Mathematics and Information Sciences

Automated Management of Documents

A report presents the main technical issues involved in computer-integrated documentation. The problems associated with the automation of management and maintenance of documents are analyzed from perspectives of artificial intelligence and human factors. Technologies that may prove useful in computer-integrated documentation are reviewed: these include conventional approaches to indexing and retrieval of information, the use of hypertext, and knowledge-based artificial-intelligence systems. A particular effort was made to provide an appropriate representation for contextual knowledge, including generation of contexts on hypertext links. Thus, it was found that indexing of documents in computer-integrated documentation is sensitive to contexts. Theoretical considerations of navigation in hyperspace, acquisition of indexing knowledge, and maintenance of large bodies of documentation are discussed.

This work was done by Guy Boy of Sterling Software for **Ames Research Center.** *To obtain a copy of the report, "Computer Integrated Documentation,"* ***write in 54*** *on the TSP Request Card.*
ARC-13241

Spurious Numerical Solutions of Differential Equations

A paper presents a detailed study of spurious steady-state numerical solutions of differential equations that contain nonlinear source terms. Such model equations, along with applicable boundary conditions, are used to represent a baseline study for phenomena such as chemically reacting flows (e.g., in combustion). The equations are often solved numerically by time-marching methods, and the numerical solutions can sometimes diverge, oscillate, or converge to erroneous solutions, depending on the spatial and temporal discretizations, initial conditions, and the numerical boundary conditions used in the numerical (e.g., finite-difference) schemes: the recognition of this fact has given rise to an interdisciplinary field of study that has been called "the dynamics of numerics and the numerics of dynamics."

The main objectives of this study are (1) to investigate how well numerical steady-state solutions of a model nonlinear reaction/convection boundary-value problem mimic the true steady-state solutions and (2) to relate the findings of this investigation to implications for the interpretation of numerical results from computational-fluid-dynamics algorithms and computer codes that have been used to simulate reacting flows.

This work was done by A. Lafon and H. C. Yee of **Ames Research Center.** *To obtain a copy of the report "Dynamical Approach Study of Spurious Steady-State Numerical Solutions of Nonlinear Differential Equations — III. The Effects of Nonlinear Source Terms and Boundary Conditions in Reaction-Convection Equations,"* ***write in 56*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-13209.

More About Spurious Numerical Solutions of DEs

A paper discusses the reliability of the time-dependent approach to numerical solution of nonlinear differential equations (DEs) that describe steady-state behaviors of physical systems. The time-dependent approach was followed in the related study described in the preceding article, "Spurious Numerical Solutions of Differential Equations" (ARC-13209). In the time-dependent approach, an approximate numerical solution for the steady state is obtained by numerically solving a time- or pseudotime-dependent version of the discretized counterpart(s) of the applicable ordinary or partial differential equation(s) and approaching the steady state asymptotically. The asymptotic results can sometimes converge or fail to converge to the true solutions, or converge to erroneous solutions that satisfy the discretized counterparts but not the underlying differential equations.

The paper notes that nonlinear dynamics and local and global bifurcation theory can be used to analyze and explain much of the asymptotic behavior of the discretized counterparts.

One of the conclusions drawn from the results of this study and the study described in the preceding article is that the use of a time step smaller than the linearized stability limit does not necessarily result in a true approximation to the exact solution, even though the initial data might be physically relevant.

The paper presents a comparison of the guidelines, assumptions, usage, and applicability of nonlinear, and of three methods of linear, stability analysis. It concludes, from the comparison, that nonlinear analysis uncovers many of the nonlinear phenomena that cannot be predicted by linearized analysis.

This work was done by H. C. Yee of **Ames Research Center** *and P. K. Sweby of the University of Reading. To obtain a copy of the report, "On Reliability of the Time-Dependent Approach to Obtaining Steady-State Numerical Solutions,"* ***write in 50*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-13208.

Physical Sciences

Scattering of Nonplanar Acoustic Waves

A report presents a theoretical study of scattering of nonplanar acoustic waves by rigid bodies. The study was performed as part of an effort to develop means of predicting scattering, from aircraft fuselages, of noise made by rotating blades. The basic approach taken in the study was to model acoustic scattering by use of a boundary integral equation

to solve the equation by the Galerkin method. This approach was followed in solving example problems that involved point acoustic sources. The computations by the present approach were found to converge on the exact solutions much faster than would computations performed with infinite series according to the method of separation of variables.

This work was done by Judith M. Gillman of **Ames Research Center**, *F. Farassat of Langley Research Center, and M. K. Myers of George Washington University. To obtain a copy of the report, "A Boundary Integral Approach to the Scattering of Nonplanar Acoustic Waves by Rigid Bodies,"* ***write in 7*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-12837.

Electronic Components and Circuits

Fundamental Limitations of Passive Power Dividers

A report presents a novel theoretical analysis of the performance of passive, multiport power dividers like those used to distribute power to the radiating elements of array antennas. Typically, a unit cell of a power-divider network is a three- or four-port subnetwork with one port terminated, and the subnetworks of a network are cascaded in multiple layers, so that insertion losses are of major concern. Starting with general equations for a passive power divider, the report derives a Hermitian dissipation matrix, **Q**, that can be expressed in terms of the traditional scattering matrix, **S**. Each eigenvalue of **Q** represents the fraction of power dissipated in the network when the network is excited by an incident wave represented by the corresponding eigenvector. The general properties of Hermitian matrices and the more specific mathematical properties that represent passivity are used to draw conclusions about these eigenvalues and eigenvectors and the corresponding implications for power-division performance. The effects of geometrical factors in conductors with dimensions that are appreciable fractions of wavelengths, and thus cannot be accurately modeled as lumped circuit elements, are also considered. It is shown that passivity and geometrical factors impose fun-

damental limits on performance, beyond the limits imposed by losses in dielectrics and in the resistances of conductors.

This work was done by Dimitrios Antsos of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Implications of Passivity on Power Division,"* ***write in 25*** *on the TSP Request Card. NPO-19600*

Study of Corrosion of Lead-Sheathed Cables

A report presents a statistical analysis of corrosion failures of the lead-sheathed cables that serve as the primary communication links at Kennedy Space Center. Most of these cables were installed during the years 1962 through 1964, and cathodic protection was added to some parts of the cable network in 1971 and to other parts of the network in 1980. However, corrosion failures continued to occur. In the study, corrosion-failure data were analyzed by use of the Weibull distribution in the effort to assess the effectiveness of cathodic protection and to predict future failures.

This work was done by Rupert U. Lee of **Kennedy Space Center.** *To obtain a copy of the report, "Statistical Analysis of Corrosion Failures of Lead-Sheathed Cables,"* ***write in 20*** *on the TSP Request Card. KSC-11627*

Mechanics

Alternative Habitats for First Lunar Outpost

A report describes an investigation of alternative design concepts for habitable structures at an outpost to be established on the Moon. Beginning with a baseline habitat concept derived from a habitat module of the Space Station Freedom, the investigation was directed toward modification of the baseline design to achieve five design goals. The first goal was better access by personnel to the surface of the Moon. For example, the airlock could be relocated under the habitat for easier access. Alternatively, the landing spacecraft could be modified to lower the habitat closer to the lunar surface so that the height for lifting objects would be reduced. The second goal was to provide for future expansion of the outpost by disconnecting the habitat module from the landing spacecraft and moving and connecting it to other modules at the outpost. Provisions for achieving these goals could include ramps, suspension cables, hoists, and equipping modules with limited capabilities as wheeled land vehicles. The third goal was increasing habitable volume. This could be done by redesign and by use of spent fuel tanks as enclosures for additional habitable space. The fourth goal was protection against radiation; no specific action toward this goal was proposed. The fifth goal was reduction of the overall mass. This could be accomplished by redesign, using lightweight materials like aluminum/lithium and metal-matrix composites.

This work was done by Charles R. Fowler, Kauser S. Imtiaz, Irwin E. Vas, and Gordon R. Woodcock of the Boeing Co. for **Marshall Space Flight Center.** *To obtain a copy of the report, "Alternative Habitats for First Lunar Outpost,"* ***write in 34*** *on the TSP Request Card. MFS-28953*

LITERATURE SPOTLIGHT

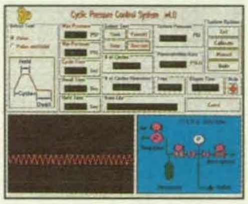
Free catalogs and literature for *NASA Tech Briefs'* readers. To order, write in the corresponding number on the Readers Information Request Form (page 99).

COMPUTER CONTROLLED VALVES

Brochure describes company's line of remote and computer controlled on-off, metering and servo valves, pressure generators, automated pressure and flow control systems, pressure gauge calibration systems and capability for custom configurations. Pressure range: high vacuum to 60,000 psi. Tel: 607-257-5544. Toll Free in USA and Canada: 1-800-825-5764. Fax: 607-257-5639. Address: 83 Brown Road, Bldg. 4, Ithaca, NY 14850.

Advanced Pressure Products

For More Information Write In No. 300

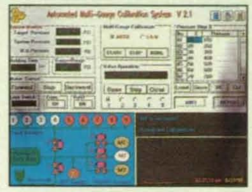


CYCLIC PRESSURE CONTROL SYSTEM

C.P.C.S. is a Windows-based automatic cyclic pressure control system. It supplies pneumatic or liquid cyclic pressure between the maximum and minimum values at a given fixed rate, allowing fatigue tests of a variety of samples such as artificial arteries. Tel: (607) 257-5544; from USA & Canada: 800-APP-VALVE; FAX: (607) 257-5639.

Advanced Pressure Products

For More Information Write In No. 301

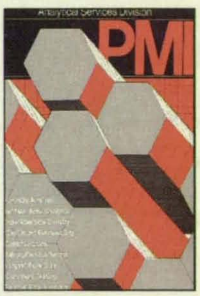


AUTOMATED PRESSURE GAUGE CALIBRATION SYSTEM

Fully Programmable Automated Pressure Gauge Calibration System, available in pressure ranges from vacuum up to 60,000 psi: Windows Control software provided. Both electronic and mechanical overpressure fail-safe systems with automatic pressurizing fluid refill system. Advanced Pressure Products; Tel: 607-257-5544; from USA and Canada: 800-APP-VALVE; Fax: 607-257-5639.

Advanced Pressure Products

For More Information Write In No. 302



PMI ANALYTICAL SERVICES

Porous Materials Inc. offers sample testing services to determine:

- Gas and liquid permeability
- Bubble point–largest pore size
- Bulk and absolute density
- BET single and multi-point surface area
- Filter integrity
- Pore analysis using mercury/non-mercury intrusion
- Adsorption/desorption isotherms, physisorption or chemisorption (H_2, CO, H_2O, NH_3, CO_2, and other gases), liquisorption
- Particle size analysis

Porous Materials Inc.; Tel: 607-257-5544; from USA and Canada: 800-TALK-PMI; Fax: 607-257-5639.

Porous Materials Inc.

For More Information Write In No. 303

APP ANALYTICAL SERVICES

Advanced Pressure Products offers a complete line of pressure and flow related services, including the following:

- Isostatic pressure testing
- Burst testing
- Compression testing
- Pressure gauge calibration
- Flow meter calibration
- Fatigue testing
- Leak testing

Advanced Pressure Products; Tel: 607-257-5544; from USA and Canada: 800-APP-VALVE; Fax: 607-257-5639.

Advanced Pressure Products

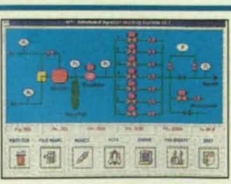
For More Information Write In No. 304

APP CUSTOM CONTROL SYSTEMS

APP can custom-design control systems to meet your pressure and flow control needs. A full line of pressure and flow gauges, generators, regulators and valves can all be computer-controlled to solve virtually any problem you may have. Types of projects include partial or complete process control for improved product performance, specialized product testing, automated instrumentation & laboratory automation. Choice of just consultation, design and documentation, or complete turnkey systems available. Advanced Pressure Products; Tel: 607-257-5544; from USA and Canada: 800-APP-VALVE; Fax: 607-257-5639.

Advanced Pressure Products

For More Information Write In No. 305



GAS-ASSIST INJECTION MOLDING UNIT

APP, the world leader in pressure and flow control systems, announces the first PC-controlled gas-assist injection molding equipment (using Windows software). This flow control system allows for varied wall thicknesses and provides unsurpassed control over velocity of advancing plastic melt front. If you are in the injection molding business, you must contact us to hear about this revolutionary new control technique and 21st century control software!! Advanced Pressure Products; Tel: 607-257-5544; from USA and Canada: 800-APP-VALVE; Fax: 607-257-5639.

Advanced Pressure Products

For More Information Write In No. 306

APP POSITION CONTROLLED VALVE

The Advanced Pressure Products Remote Position Controlled Valve provides a very cost-effective remote controller for metering valves. The valve is controlled by a single analog voltage which determines the desired position of the valve. The controller moves the valve to match this target position. Automatic limit protection is provided. Control can be provided from a sample remote potentiometer, analog voltage or milliamp output. Advanced Pressure Products, Cornell U. Research Park, Bldg. 4, 83 Brown Rd., Ithaca, NY 14850-1298. Tel: 1-800-APP-VALVE (1-800-227-8258).

Advanced Pressure Products

For More Information Write In No. 307

PMI COMPLETE FILTER ANALYZER

The PMI Complete Filter Analyzer can solve all of your filter testing needs. It combines tests for bubble point, gas permeability (liquid permeability is optional), pore distribution, and filter integrity. Raw filter material and complete filter cartridges can be tested. Porous Materials Inc.; Tel: 607-257-5544; from USA and Canada: 800-TALK-PMI; Fax: 607-257-5639.

Porous Materials Inc.

For More Information Write In No. 308

Apec high-heat polycarbonate, known for its unique combination of high heat resistance, toughness, transparency, color stability and flowability, is described in a new 16-page color brochure issued by the Polymers Division of Bayer Corporation, Pittsburgh, PA. The brochure shows typical applications for this material, and provides information on flame retardance, chemical and stress crack resistance, solubility and processing methods. Bayer Corp., Polymers Division, 100 Bayer Road, Pittsburgh, PA 15205-9741; Tel: 412-777-2000.

Bayer Corp., Polymers Division

For More Information Write In No. 309

Parts Libraries - Computervision

Libraries of compiled macros for **CADDS 5 & CADDS 4X** create a wide variety of standard hardware items.

SOLIDS & WIREFRAME, INCH & METRIC

Programs will create all fastener holes • hex nuts • bolts all screws (soc. hd., slotted, phillips) • washers (flat, lock, spring) • pins (dowel, split, cotter, spiral) • retaining rings & grooves • structural beams (all) • pipe fittings • springs (compression, extension, torsion) • thread inserts & holes. 1000's of parts. Bill of Materials programs **automate** the process of tracking and creating BOMs, including **creation of graphic BOM table** and **part labels,** works without CADDS Data Extract. Full 30 day **DEMO available.**

□ Also available: **Layer Management System** - automates layer lists, layer changes to models, much, much more.

Design Solutions Software Co.

Glen Mills, PA 19342 (610) 358-4054

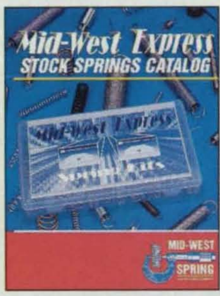
For More Information Write In No. 310

TIME AND FREQUENCY PRODUCTS

TrueTime's Precision Time and Frequency Products catalog features GPS-Synchronized Clocks in rackmount, portable, and board-level configurations. Included are illustrations and product specs for Synchronized Clocks, Time Code Products, Board Level Products and Remote Displays. TrueTime products fit a variety of time and frequency applications. TrueTime, Inc., 2835 Duke Court, Santa Rosa, CA 95407; Tel: 707-528-1230; Fax: 707-527-6640; E-mail: truetime@nbn.com.

TrueTime, Inc.

For More Information Write In No. 311

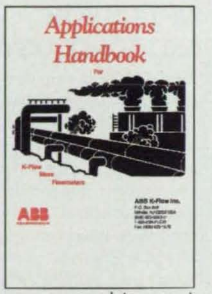


MID-WEST EXPRESS STOCK SPRINGS CATALOG

New, 56-page catalog describes over 1,500 different stock springs and spring kits available for immediate delivery. Compression, extension, torsion, continuous, hot wound, die, extension and specialty springs are described. Mid-West Express, a division of Mid-West Spring Manufacturing Company, 1404 Joliet Road, Unit C, Romeoville, IL 60441; Tel: 800-619-0909.

Mid-West Express

For More Information Write In No. 312

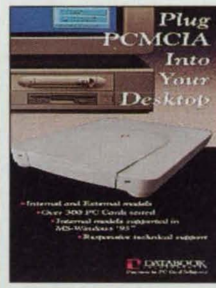


MASS FLOW METER APPLICATIONS HANDBOOK

The new handbook consists of a series of K-Flow application solutions. The "Application Handbook" illustrates the flow process configuration and ABB K-Flow flowmeter/transmitter systems used in a variety of process applications. Applications covered include Mass (Liquid, Gas, Multi-Component), Density (SG, API, Brix), %Solids, %Liquids, PID, Ratio Blending, Batching, Proportioning, etc.

ABB K-Flow

For More Information Write In No. 313



PCMCIA DESKTOP ADAPTORS

The PCMCIA standard is the newest technology in data storage and I/O for desktop and mobile computers. Now ENVOY DATA offers the most complete line of PCMCIA Databook adaptors (reader/writers) for your desktop computer. External models connect through the parallel port while internal models use an ISA interface card. All models read and write Types I, II, or III memory cards. Tel: 602-892-0954; Fax: 602-892-0029.

Envoy Data Corporation

For More Information Write In No. 314

PIEZOELECTRIC CERAMICS

A 28-page brochure is a design guide for piezoelectric ceramics in a variety of shapes and sizes. Piezoelectric and electromechanical properties for various PZT materials (lead zirconate titanate) are included, and various types of piezoceramic configurations, including stacks and bimorphs® are described. Tel: 216-232-8600; Fax: 216-232-8731.

Morgan Matroc Inc.

For More Information Write In No.315

HEIDENHAIN METRO INCREMENTAL LENGTH GAGES

This 24-page HEIDENHAIN catalog features Metro and Certo digital height gages, designed for a variety of applications, including part, position and motion measurement. These gages can be used in the manufacturing environment, both as in-process and post-process inspection gages. Also ideal for inspecting parts, monitoring, and calibration of measuring standards. HEIDENHAIN Corporation, 115 Commerce Drive, Schaumburg, IL 60173; Tel: 708-490-1191.

HEIDENHAIN CORPORATION

For More Information Write In No. 316

TECHNICAL FIBRE PRODUCTS MATERIAL ADVANTAGE

TFP is an Advanced Fiber Nonwoven Manufacturer that produces veils varying from 0.2-8.0 oz/yd^2 from virtually any fiber type. Examples are Carbon, Aramid, Quartz, Silcon Carbide, Metal-coated and Glass. TFP's accurate fiber blending technology can result in a hybrid, provide a specific resistivity level or utilize a thermoplastic fibre for molding. TFP also produces Intumescent mat for fire protection. Tel: 914-355-4190; Fax: 914-355-4192.

Technical Fibre Products Limited

For More Information Write In No. 317

ENGINEERED MAGNESIUM & ALUMINUM CASTINGS

The company, founded in 1945, is a specialist in prototype and production castings for the aerospace, automotive and commercial industries. Advanced quality and production control systems comply with ISO-9000 International Aerospace and all leading government, commercial, military and automotive specifications. Mechanized green sand, dry sand and permanent mold processes. On-site heat treating. In-house testing and laboratory facilities. Tel: 216-581-9200; Fax blueprints: 216-475-6611 for prompt quotes.

Thompson Casting Co. Inc.

For More Information Write In No. 318

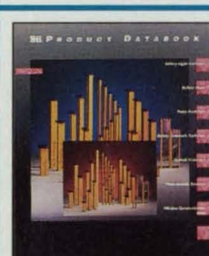
MANUAL & MOTORIZED POSITIONING SYSTEMS

Daedal's new 300-page catalog provides specifications for cross roller and ball slides; center and side drive cross roller tables; closed and open frame motorized tables; rail tables; manual and motorized rotary tables; digital micrometer stages; single and multi-axis motion controllers; half-step, microstepping, and servo motor drives; and optical positioners and hardware.

Daedal Div., Parker Hannifin Corp.

Tel: 800-245-6903; Fax: 412-744-7626.

For More Information Write In No. 319



SAFETY PRODUCTS FOR MACHINE GUARDING

STI's Product Databook features Safety Light Curtains, the most advanced machine guarding technology. Light curtains offer a more effective guard zone than conventional barriers and fencing for use around machine perimeters, robots, and work cells. Additional safety products include safety mats, palm switches and safety interlock switches designed to international standards. Scientific Technologies Inc., 31069 Genstar Road, Hayward, CA 94544-7831; Tel: 800-221-7060; Fax: 510-471-9752. STI205a.

Scientific Technologies Inc.

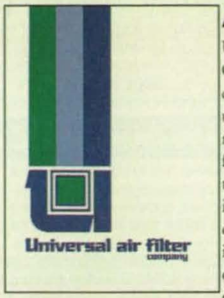
For More Information Write In No. 320

PRECISION MOTION CONTROL

API's 1995/96 172 page step motor systems catalog, featuring the new Intelligent Drive series, contains motion control technical, application and product data. Definitions, market applications, comparison charts, specifications and diagrams simplify the selection process. API products range from full/half-step driver modules to high performance microstep systems. American Precision Industries, Motion Technologies Group, Controls Div., 45 Hazelwood Drive, Amherst, NY 14228; Tel: 716-691-9100; Fax: 716-691-9181.

American Precision Industries

For More Information Write In No. 321

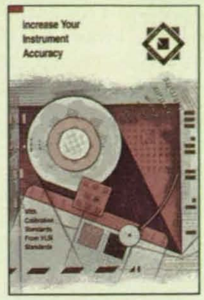


AIR FILTERS

Universal Air Filter Company manufactures custom-designed filter products for original equipment manufacturers. Universal filters are used extensively in the electronics, HVAC, digital switch, medical, defense, and data processing industries. The brochure describes applications and engineering and production capabilities. Universal Air Filter Company, 3400 Missouri Avenue, East St. Louis, Illinois 62203. Tel: 800-541-3478; Fax: 618-271-8808.

Universal Air Filter Company

For More Information Write In No. 322



CALIBRATION STANDARDS CATALOG

Free 1995 catalog of metrology calibration standards for surface contamination, critical dimensions, film thickness, surface profiling, characterization and more. Important for ISO 9000 certification. From VLSI Standards, 3087 North First St., San Jose, CA 95134; Tel: 408-428-1800; Fax: 408-428-9555.

VLSI Standards

For More Information Write In No. 323

REMOTE VIEWING INSTRUMENTS (RVI)

If you have requirements to observe or visually inspect items located in inaccessible areas or hostile environments, select from over 1800 RVI's outlined in this new product catalog from ITI. Borescopes, Fiberscopes and Videoscopes to provide sharp, clear images never before available. INSIGHT from the "Leader in Remote Viewing." Instrument Technology, Inc. Tel: 413-562-3606; Fax: 413-568-9809.

Instrument Technology, Inc.

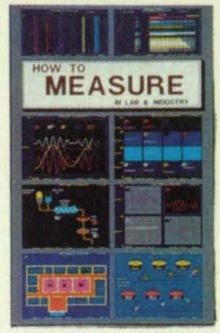
For More Information Write In No. 324

OPTICS FOR METEOROLOGY

New 1995 Catalog contains 120 pages of information and prices on toolmaker's microscopes, stereo microscopes, alignment microscopes, monocular zoom microscopes, microtelescopes, pocket microscopes, borescopes, micro video lenses, and fiber optic and miniature illumination systems. Also described are centering microscopes, optical cutting tool geometry analyzers, X-Y tables, and micro-finishing equipment. Tel: 716-873-9907; Fax: 716-873-9998.

Titan Tool Supply Co., Inc.

For More Information Write In No. 325



HIGH RESOLUTION DATA ACQUISITION

FREE booklet shows many ways to automate data collection using your personal computer. It comes with a FREE Instatrend Real-Time Graphics Demo Disk. Dianachart, Inc., 101 Round Hill Drive, Rockaway, NJ 07866. Tel: 201-625-2299.

Dianachart, Inc.

For More Information Write In No. 326

OVENS & FURNACES UP TO 2700 °F

Capabilities, specifications and prices for over 250 standard ovens and furnaces to 2700 °F as well as custom-designed heat processing systems. Includes: laboratory, bench, cabinet, truck, walk-in and conveyor ovens; clean room and pharmaceutical ovens; laboratory and industrial furnaces and environmental test chambers. For baking, drying, pre-heating, annealing, stress relieving, curing, sterilizing, depyrogenation and heat treating. Tel: 708-546-8225.

The Grieve Corporation

For More Information Write In No. 327

THERMACAM™ FPA IR CAMERA

ThermaCAM™, a palm-sized focal plane array (FPA) infrared (IR) camera, combines state-of-the-art focal plane array technology with full infrared temperature measurement capabilities. ThermaCAM weighs less than six pounds complete with battery, color viewfinder and interchangeable lenses; it offers ultra-high resolution, 12 bit dynamic range, on-board digital signal processing and PCMCIA storage. Inframetrics, Inc., 16 Esquire Road, N. Billerica, MA 01862; Tel: 508-670-5555; Fax: 508-667-2702.

Inframetrics, Inc.

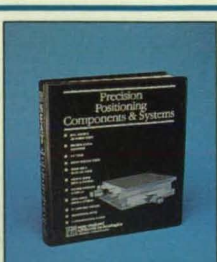
For More Information Write In No. 328

PARTS EXPRESS

Our FREE catalog features 212 pages packed with electronic parts for the do-it-yourselfer. Over 12,000 items including speakers, semiconductors, tools, wire, capacitors, hardware, test equipment, kits, connectors, adhesives, educational books and videos, TV parts, and much more. Call toll free 800-338-0531. Parts Express, 340 E. First St., Dayton, OH 45402.

Parts Express International Inc.

For More Information Write In No. 329



POSITIONING/ MOTION CONTROL CATALOG

NEW, detailed 160 page catalog covers NEAT's expanding line of precision positioning and motion control components and systems. Featured are single axis, X-Y, multi-axis, rotary, high vacuum, air bearing, and microscope stages. NEAT also provides a complementary line of stepping and servometer drives and controls. NEAT specializes in providing modified, custom, and turnkey SOLUTIONS to a wide range of positioning and motion control applications. Please contact our Sales Engineers at 800-227-1066, or send E-mail to neat@tiac.net for more information.

New England Affiliated Technologies

For More Information Write In No. 330

"HANDS-ON" ADVANCED COMPOSITE WORKSHOPS—SINCE 1983

The brochure describes 13 different "hands-on" workshops in advanced composite materials technology. These workshops cover fabrication, repair, manufacturing, tooling, blueprint reading, adhesive bonding, ultrasonic inspection of composites, and 4 engineering workshops. Emphasis is placed on prepreg carbon and aramid fiber materials and processes, utilizing vacuum bagging and high-temperature curing methods in the oven and autoclave. Three workshops are Canadian DOT approved. REFRESHER WORKSHOPS OFFERED. For a free brochure, call 1-800-638-8441; Fax: 702-827-6599.

Abaris Training Resources

For More Information Write In No. 331

ELECTROMAGNETIC DESIGN SOFTWARE

The legendary Vector Fields suite of software, including the TOSCA, ELEKTRA and OPERA packages, combines classical finite element techniques with user friendly interactive graphics for high accuracy 2D and 3D simulation and design of all types of electromagnetic equipment.

Vector Fields Inc.
1700 North Farnsworth Avenue
Aurora, IL 60505
Tel: 708-851-1734 Fax: 708-851-2106

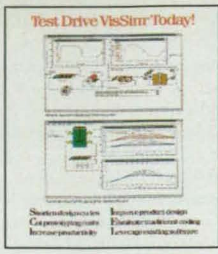
For More Information Write In No. 332

AFFORDABLE VACUUM ACCESSORIES

New vacuum accessories catalog features over 800 affordable products including flanges, fittings, construction components, valves, vacuum gauges and residual gas analyzers. These high quality products are backed by Balzers technical service and support. In-stock items are shipped within 48 hours. Visa and MasterCard are accepted. Balzers, 8 Sagamore Park Road, Hudson, NH 03051; Tel: 603-889-6888; Fax: 800-555-3173; for orders toll-free: 800-555-3172.

Balzers

For More Information Write In No. 333



QUIT GUESSING SIMULATE IT WITH VISSIM™

VisSim is an innovative block diagram language for nonlinear dynamic simulation. VisSim's uniquely integrated approach to model construction and execution leads to rapid prototyping, faster execution, and greater productivity. NEW! Version 2.0 has MMI. Call: 508-392-0100 or Fax: 508-692-3102. Visual Solutions, Inc., 487 Groton Rd., Westford, MA 01886. FREE WORKING DEMO.

Visual Solutions, Inc.

For More Information Write In No. 334

NEW 1995-96 COLE-PARMER® INSTRUMENTS CATALOG

The new, free 1995-96 Cole-Parmer instruments catalog contains over 1700 full-color pages and features more than 40,000 products covering scientific instruments, equipment, and supplies. The catalog includes a detailed 40-page product index and table of contents, informative introductory pages for many of the catalog sections, "Hot Tips," and an 8-page section of late-breaking products. Contact Cole-Parmer Instrument Company—in the USA or Canada, call toll-free 1-800-323-4340.

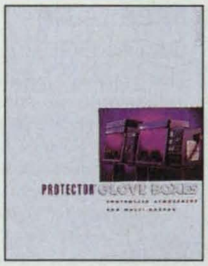
For More Information Write In No. 335

FREE ACCESS TO FEDERALLY FUNDED TECHNOLOGY

National Technology Transfer Center offers free access to federally funded technology, an electronic bulletin board announcing technology transfer opportunities, training on technology transfer issues, and strategic partnering conferences. Why not call (800) 678-6882 today and discover the research opportunities right at your fingertips.

National Technology Transfer Center

For More Information Write In No. 336



GET YOUR HANDS ON THE PROTECTOR® GLOVE BOXES CATALOG

Thumb through this 28-page, full-color catalog detailing Labconco's controlled atmosphere and multi-hazard glove boxes. Find complete information on built-in options including the automatic pressure controller with foot pedal and purge/fill controller. Call 800-732-0031.

Labconco

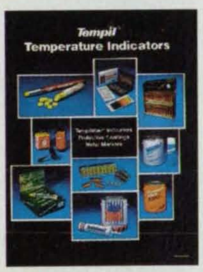
For More Information Write In No. 337

TOOLS, TOOL KITS, CASES & TEST EQUIPMENT

Installation/repair tools, tool kits, test equipment, telecom equipment, LAN testers & instrument/shipping cases are detailed in this 300+ page full-color catalog. Includes products for field service & depot repair. Indexed catalog features over 100 standard tool kits & complete information on "customizing" to meet specific customer requirements. Complete specs & prices are provided for all products. Tel: 800-866-5353; Fax: 800-234-8286.

Specialized Products Co.

For More Information Write In No. 338



TEMPERATURE INDICATORS AND MONITORS

This most extensive line of temperature indicating products includes sticks, label monitors, indicating liquids and pellets for preheat/post-heat welding. The 8-page catalog discusses hand test kits, metal markets and protective coatings. Applications cover welding, metal-working, electronics, nuclear and machinery. Tempil Division, Tel: 908-757-8300; Fax: 908-757-9273.

Air Liquide America Corp.

For More Information Write In No. 339

SMALL COMPONENT ASSEMBLY SYSTEMS

An introduction to the Injected Metal Assembly™ process, used to join small components using a specialized die casting technique. Details provided on complete engineering services and contract assembly services that are available. Call 800-691-3322, ext. 3010. Fishertech Division, Fisher Gauge Limited, PO Box 179, Peterborough, Ontario, Canada K9J 6Y9.

Fisher Gauge Limited

For More Information Write In No. 340

HUNTER MINI-PLATING PENS

Low-cost disposable applicators permit instantaneous selection from a variety of plating possibilities without preparation of solutions. Specially formulated plating compounds can be used anywhere; prototype development work, electronic instrument repair, contact repair, etc. Pens available: copper, tin, zinc, nickel, black nickel, silver, chrome-color, rhodium, palladium and gold (24, 18, and 14K). Tel: 908-526-8440. Fax: 908-526-8348.

Hunter Products, Inc.

For More Information Write In No. 341

LOW-COST PC-COMPATIBLE DATA LOGGER

Puts eight thermo couple channels on monitor, printer, or disk for $279 complete. Specifically for laboratory and industrial temperature monitoring. Avoids complex set-up or installation and is functioning within minutes. RS-232 interface powers converter and eliminates sensor wires at computer. Quick-Basic®MS source code and compiled program provided. 16-channel and linear sensor options. Tel: 609-662-7272.

DCC Corporation

For More Information Write In No. 342

MONITOR, RECORD & ANALYZE

Astro-Med's 32-channel recorder with built-in monitor, 170 Mbyte internal hard drive and front-panel floppy drive is described in this illustrated 20-page brochure. The unit, called the MT95K2, features extraordinary capabilities including three on-board analysis programs, Windows host control, Windows data analysis, and a wide variety of sophisticated data capture options. Tel: 800-343-4039; Fax: 401-822-2430.

Astro-Med Inc.

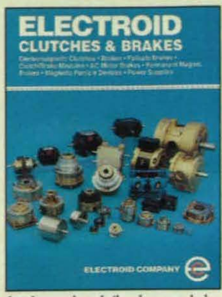
For More Information Write In No. 343

ELECTROMAGNETICS

Electromagnetic field simulation software for electromechanical designers. Visualize field patterns and flux paths. Solve for force, torque, inductance and other electrical parameters on your desktop computer. Call for information on Maxwell EM. Ansoft Corporation; Tel: 412-261-3200; Fax: 412-471-9427.

Ansoft Corporation

For More Information Write In No. 344



ELECTRO-MAGNETIC CLUTCHES & BRAKES

New 128-pg. catalog of ELECTROID's electromagnetic products for rotary motion control. Pictures, drawings, specs and technical data on clutches, brakes, failsafe brakes, clutch/brake modules, AC motor brakes, permanent magnet brakes, reversing drives, magnetic particle devices, power supplies, etc.

ELECTROID

For More Information Write In No. 345

The Capattery is a high-reliability double layer capacitor used as a standby power source in memory back-up and bridge-power applications. It has virtually unlimited cycle life and over 20x the capacitance density of conventional capacitors. With a Permselective valve, patented by Evans, 33 Eastern Ave., East Providence, RI 02914-2107, Tel: 401-434-5600; Fax: 401-434-6908.

Evans

For More Information Write In No. 346

FREE! CATALOG FROM MCM ELECTRONICS

MCM is the industry leader in the distribution of consumer electronic repair parts and equipment. Catalog #36 includes test equipment from Tenma, Fluke and B&K, semiconductors, and much more. Over 21,000 items are in stock and ready to ship from distribution centers near Reno, NV and Dayton, OH, providing two day shipping to most of the continental US. A "must have" for all service technicians and electronics enthusiasts. Tel: 800-543-4330. TB02

MCM Electronics

For More Information Write In No. 347

WAVE/COMPRESSION SPRINGS

Just updated, Catalog #WS-93 contains **NEW stock sizes** of wave/compression springs available from stock, including spring design formulas, materials guide and typical applications. The manual describes the many advantages of Smalley's exclusive edgewinding manufacturing process. Smalley springs, available from 3/8" to 84" in diameter, are produced by circle-coiling flat wire to exact specifications involving **no dies or special tooling charges**. Tel: 708-537-7600; Fax: 708-537-7698.

Smalley Steel Ring Co.

For More Information Write In No.348

FREE LAMP CATALOG

This catalog features replacement lamps at discount prices for all types of equipment. Lamps for audio-visual, photographic, micrographic, and graphic arts equipment. 100% guaranteed brand names–toll-free ordering–no minimum order. All deliveries via Second-Day Air at NO extra cost. Also, lamps for medical and electronic instruments, microscopes and video use. Tel: 800-772-5267; Fax: 800-257-0760. PSC Lamps Inc., 1 Fishers Road, Pittsford, NY 14534-9511.

PSC Lamps Inc.

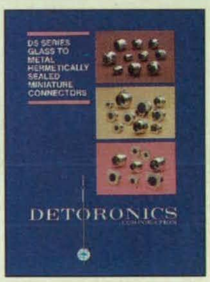
For More Information Write In No. 349

MERCURY ROTATING ELECTRICAL CONNECTORS

Mercury-wetted contacts are covered in brochure. They are superior to conventional slip rings and feature sealed, ball bearing construction. Durable, compact, low-cost connectors offer reliability, extremely low electrical noise, and less than 1 milliohm resistance. Ideal for computers, instrumentation, thermocouples, cable reels, strain gauges, packaging equipment, robotics, turntables, testing, and control devices. Mercotac Inc., 6195 Corte del Cedro #100, Carlsbad, CA 92009.

Mercotac Inc.

For More Information Write In No. 350

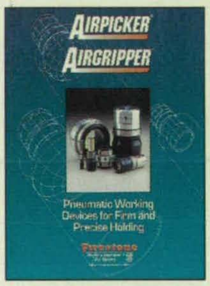


SEALED THREADED CONNECTORS

Brochure provides information on finishes and diagrams of pin contact arrangements of the DS series glass-to-metal hermetically sealed miniature connectors used where Vacuum, Gas or constant Pressure is required for Sensors, Valves, Instruments or Refrigeration. Detoronics Corp., 10660 East Rush St., So. El Monte, CA 91733-3432; Tel: 818-579-7130; Fax: 818-579-1936.

Detoronics Corp.

For More Information Write In No.351

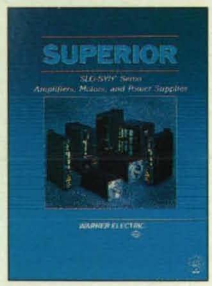


PNEU END EFFECTORS

Move it, hold it, pick it up, collar it, position it with Firestone Industrial Product Company's new pneumatic end effectors–AirPickers® and AirGrippers™. They combine air pressure control with the slip resistance of rubber for gentle yet sturdy component handling. New brochure includes product specs and selection criteria. Firestone Industrial Products Company, Carmel, IN; Tel: 800-888-0650.

Firestone Industrial Products

For More Information Write In No. 352



SERVO SYSTEMS

Catalog SVO-595 describes SLO-SYN® SS2000 Servo Systems consisting of motors, amplifiers, controls and power supplies. Brushless motors employ resolver feedback and are precisely matched to amplifiers. Torque ratings from 7.44 to 708 in-lb continuous. Three-phase, sine wave, brushless amplifiers have peak power rating of 6 to 110 A RMS. Control-amplifier combination utilizes 1 or 2 axis. Windows-based, icon-driven programming utility and BASIC-like commands. Superior Electric, 383 Middle Street, Bristol, CT 06010; Tel: 800-787-3532 or 860-585-4500.

Superior Electric

For More Information Write In No. 353

QUIET COMPRESSED AIR!

JUN-AIR's new brochure shows you only a few of the possibilities. Compressors range from oil-lube to oil-less, 110V DC, 0.25-3.0 HP, 0.7-11.0 cfm, maximum pressure 120 psi. Vacuum pumps and custom-designed compressors to customers' specifications also featured. Join over 250,000 satisfied customers in over 50 countries worldwide enjoying their JUN-AIR compressors. Ask about our line of "Quiet" compressors. Tel: 800-4JUN-AIR.

JUN-AIR

For More Information Write In No.354

NEW! OPTICAL REFERENCE CATALOG

Edmund Scientific's free 228-page, color technical reference catalog features one of the largest selections of precision off-the-shelf optics and optical instruments, plus a complete line of components and accessories for both large volume OEM users as well as smaller research facilities and optical laboratories. Contains over 8,000 hard-to-find items, including a large selection of magnifiers, magnets, microscopes, telescopes, and "machine vision" products. Tel: 609-573-6259; Fax: 609-573-6233.

Edmund Scientific Co.,
Dept. 15B1, N954

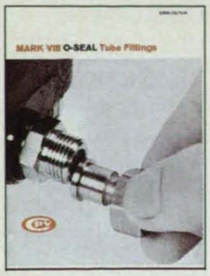
For More Information Write In No. 355

MICRO-TRACK DIGITAL CASSETTE RECORDING

This new 60-page handbook is a guide for engineers in the defense, aerospace, remote sensing and related sectors involved with capturing, processing and archiving large volumes of instrumentation data. Covers latest technologies, interfacing and applications. Available free to qualified applicants. Penny & Giles Data Systems, 3100 Medlock Bridge Road, Norcross, GA 30071; Tel: 770-448-9737 or +44 (0)1749 675454; Fax: 770-448-4719 or +44 (0)1749 676678.

Penny & Giles Data Systems

For More Information Write In No. 356

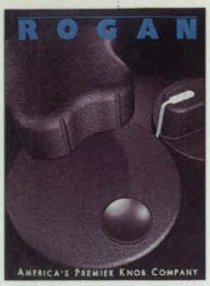


O-RING SEALED TUBE FITTINGS

Full line of flat-faced, O-ring sealed tube fittings offering slip-in/slip-out ease and leakproof connections from vacuum to 6000 psi or more described in CPV Catalog 74. Choice of steel or stainless steel in OD tube sizes from 1/8" to 2". CPV Mfg. Inc., 851 Preston St., Philadelphia, PA 19104; Tel: 215-386-6508; Fax: 215-387-9043.

CPV Mfg. Inc.

For More Information Write In No. 357

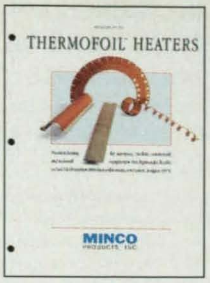


1995 ROGAN KNOB CATALOG

The complete lineup of Rogan knobs and dials–including a range of new offerings–is featured in their new fully illustrated catalog. New products included in this edition are several new Pure Touch Knobs™ such as clamping knobs in an expanded range of sizes, the all new five-lobe clamping knob and raised bar pointer knob. Rogan Corporation, 3455 Woodhead Dr., Northbrook, IL 60062; Tel: 800-423-1543; Fax: 708-498-2334.

Rogan Corporation

For More Information Write In No. 358



THERMOFOIL™ HEATERS

Bulletin HS-201 lists over 200 sizes and resistances of etched-foil heating elements. Included are Kapton, silicone rubber, and mica insulated models for aerospace, medical, and industrial devices. The 32-page catalog offers complete technical specifications, custom design information and application ideas to help the reader solve unique heating problems using Thermofoil technology.

Minco Products Inc.

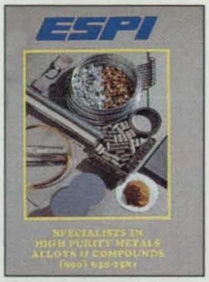
For More Information Write In No. 359

THERMAL SPRAY PRODUCTS & SYSTEMS

Free brochure describes the thermal spray process as used to apply metal, ceramic, and cermet coatings. Process has applications in the aerospace, automotive, biomedical, turbomachinery, petrochemical, power generation, and general manufacturing industries. Miller Thermal, Inc. is a full-line producer of thermal spray products and integrated thermal spray systems. Tel: 414-734-9292; Toll-free in USA and Canada: 800-637-8307; Fax: 414-734-2160.

Miller Thermal, Inc.

For More Information Write In No. 360



Available free from ESPI is their 483-page catalog containing information on high-purity metals, alloys, chemicals, single crystals, rare earths, and exotic and precious metals. The catalog is organized into nine sections: high-purity metals and compounds, alloys, sputtering targets, vacuum deposition and evaporation materials, phosphors, fasteners, single crystals, ceramics, and DeContam, ESPI's biodegradable, noncorrosive, nonfoaming cleansing agent.

Electronic Space Products International

For More Information Write In No.361

205,000 REASONS WHY YOUR AD BELONGS HERE

NASA Tech Briefs' Literature Spotlight section offers a low-cost way to reach over 205,000 industry and government LEADERS with your advertising message. These are technology managers, design engineers and scientists with tremendous buying power. The December 1995 issue is your next opportunity to use this high-impact sales tool. For more information or to reserve space in Literature Spotlight, contact your *NASA Tech Briefs* sales representative, or call Joseph Pramberger at (800) 944-NASA.

FREEPOINT 3D

Real Time 3D Modeling Tool

New! 3D Digitizer for:
* Reverse Engineering
* Rapid Prototyping
* Modeling, Design, etc.

Unique Features:
* Large volume--16'x8'x8'
* Digitize any material
* Hand-held flexibility

Call for a FREE brochure or demo: Tel: 410-381-6688; Fax: 410-290-9065.

Science Accessories

For More Information Write In No. 363

OPERATOR INTERFACE

The ProPanel® is a PC-based operator interface with a full-color, TFT active matrix LCD in a compact, environmentally sealed and rugged enclosure that meets NEMA 4/12 requirements. Touchscreen option available. The Purged ProPanel is approved for use in Class I, Division 1 and 2 and Zone 1 hazardous locations. Successful harsh environment applications include aluminum, food, pharmaceutical, and pulp and paper; hazardous location applications include offshore drilling, gas pipeline and chemical. Azonix Corporation, Billerica, MA; Tel: 800-365-1663; Fax: 508-670-6300.

Azonix Corporation

For More Information Write In No. 364

NEW LINEAR ACTUATORS

BS&A introduces new "Super Mover" electromechanical linear actuators. Super Movers are stock items with load capacities from 25 to 1000 pounds and standard strokes from 2 to 24 inches. Super Movers come with either AC or DC motors and are completely sealed and weather resistant. Clean, controllable replacement for air and hydraulic cylinders. Contact Greg Traeger, Sales Manager; Tel: 800-882-8857.

Ball Screws & Actuators Co. Inc.

For More Information Write In No. 365

NEW KIND OF VIDEO TEACHES FEA LESSONS

Finite Element Analysis In Action! is a new kind of instructional video for engineers. Live lab and computer demonstrations show how to better use any FEA software. A case study of brittle fracture–which can happen to almost any material, even steel–provides real-world examples. Two lab experiments and two FEA analyses are conducted and the results compared. Demonstrates specific modeling and analysis techniques for predicting lab results with FEA. Tel: 800-482-5467; URL: http://www.algor.com/apd.htm.

APD

For More Information Write In No. 366

BOOK DELIVERS REAL-WORLD FEA INSTRUCTION

FEA reference/textbook offers a blend of theory & real-world engineering examples. Dr. Constantine Spyrakos–well-known finite element stress & vibration analysis expert–has created a reference for all mechanical engineers from designers to "gurus." Richly illustrated hardcover book includes a disk with every example problem. Subjects include: FEA basics, element types, modeling, types of analysis & the interpretation of results. Tel: 800-482-5467; URL: http://www.algor.com/apd.htm.

APD

For More Information Write In No. 367

HOUDINI VIDEO TRAINING KIT FOR AUTOMATIC CAD-TO-FEA

Learn to use Houdini to automatically produce 8-node "brick" finite element models from CAD solid models for analysis by any FEA software. The kit includes: The world of Houdini training video; Complete training notes from Algor's 2-day Houdini seminar; A CD-ROM with models from the video for PC and UNIX; and Viewpak software to view the models on your computer. Tel: 412-967-2700; URL: http://www.algor.com.

Algor, Inc.

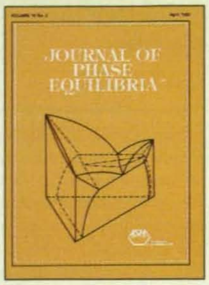
For More Information Write In No. 368

INSTRUPEDIA™ FROM NATIONAL INSTRUMENTS

National Instruments has a free new CD-ROM reference containing instrumentation information for test and measurement and process monitoring and control applications. The Windows-compatible Instrupedia features more than 60 application notes on combining hardware and software to build computer-based systems for instrument control and data acquisition, analysis, and presentation. Tel: 512-794-0100; 800-433-3488 (US and Canada); Fax: 512-794-8411; E-mail: info@natinst.com; WWW: http://www.natinst.com.

National Instruments

For More Information Write In No. 369



The *Journal of Phase Equilibria* includes original research on phase equilibria and the determination of phase diagrams and their evaluations for alloy systems. This international, peer-reviewed journal is published bimonthly and is your complete source for the latest, most accurate information available in the field. ASM International, Member Services Center, Materials Park, OH 44073-0002.

ASM International

For More Information Write In No. 370

DESIGNING WITH SILASTIC SILICONE RUBBER

Brochure highlights engineering features and physical properties of SILASTIC® silicone rubber. Outlines mechanical, electrical, and chemical properties as well as thermal characteristics and flammability. Description of specific material types, including high-strength, extreme temperature, and fuel-resistant. Typical applications include gaskets, dielectric parts, wire insulation, molded components. Dow Corning STI, 47799 Halyard Drive, Plymouth, MI 48170.

Dow Corning STI

For More Information Write In No. 371

Westinghouse Savannah River Company, Aiken, SC, just released a booklet on Savannah River Technology Center, the applied research and development laboratory at the U.S. Department of Energy's Savannah River Site. Laboratory expertise includes applications in hydrogen technology, environmental remediation, waste management, vitrification, sensor technology, and robotics and remote systems. Savannah River Technologies, Aiken, SC; Tel: 803-652-1889; Fax: 803-652-1898.

Savannah River Technologies

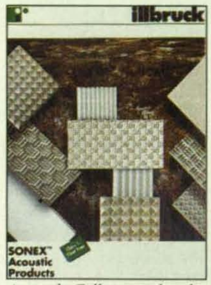
For More Information Write In No. 372

CIRCUIT SPECIALISTS FREE ELECTRONIC PRODUCTS COLOR CATALOG

128 pages, offering Industrial PCs, Data Acquisition Products, Test Equipment, Educational Robotics, Semiconductors, Desktop Computers, Computer Boards, Breadboarding Supplies, ICs, Passives, Tools, and much, much more! 24-hour Catalog Request Line: 800-811-5201, Ext. 5.

Circuit Specialists, Inc.

For More Information Write In No. 373

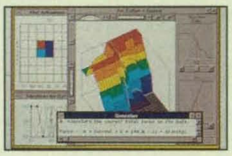


SONEX™ NOISE CONTROL

A new standard has been set in acoustical treatments and noise control materials. illbruck's SONEX products deliver the highest performance available today, with materials completely FIBER-FREE and CLASS 1 rated. Call or send today for all the product information and technical specifications. illbruck, inc., 3800 Washington Ave. North, Minneapolis, MN 55412; Tel: 800-662-0032 or 612-520-3620.

illbruck, inc.

For More Information Write In No. 374



FUZZY LOGIC TOOLS

HyperLogic offers Windows-based software for creating fuzzy logic rule-based systems. CubiCalc is an interactive environment for creating, analyzing, and using fuzzy rules. Also available: Programming tools for embedded or real-time systems in C/C++, programming support for Windows applications in C/C++ or Visual Basic, automatic rule generation software. HyperLogic Corporation; Tel: 619-746-2765 or 800-789-9780; Fax: 619-746-4089.

HyperLogic Corporation

For More Information Write In No. 375

PRECISION TEST & MEASUREMENT INSTRUMENTS

A new, full-color test and measurement catalog from Gould Instrument Systems, Inc. provides descriptions of Digital Storage Oscilloscopes, Recorders, Data Acquisition Systems, Signal Conditioners, and Analysis Software. Also included are traditional recorders and recorder products for field service and lab applications and products. For a free catalog, call 216-328-7000; Fax: 216-328-7400. Gould Instrument Systems Inc., 8333 Rockside Rd., Valley View, OH 44125.

Gould Instrument Systems Inc.

For More Information Write In No. 376

EXCELLENCE IN MOTION - 1995/1996 EDITION

The 1995/1996 edition, full-color positioning equipment technology guide from Anorad provides an overview of engineered motion control solutions for many industries. The brochure presents Anorad's broad array of positioning technologies including linear, rotary and air bearing stages; linear servo motors; gantry systems and controls. An easy-to-use selection guide is included to help users select the most appropriate equipment for their application.

Anorad Corporation

For More Information Write In No. 377

OFFICIAL NASA CAPS

Black cap with gold leaves and official NASA insignia.

Only $9.95 each!

Please send (insert quantity) ________NASA caps.
Add $5.00 for handling and shipping charges.
NY residents add sales tax.

TOTAL Enclosed: $________

NAME ____________________

ADDRESS ____________________

CITY ____________________

STATE ____________ ZIP ____________

Mail payment to: **NASA Tech Briefs, Dept F**
41 East 42nd St., Suite 921, New York, NY 10017

For credit card order call (212) 490-3999

OMEGA UNIVERSAL GUIDE TO DATA ACQUISITION & COMPUTER INTERFACES™

OMEGA Engineering Inc. announces the release of its latest publication. This 500-plus page handbook is packed with technical information and the latest product developments in automated data monitoring and control. For more information on this new literature, contact OMEGA Engineering, Inc., or use our OMEGAfax℠ service to request Document #9988 by calling 800-848-4271.

OMEGA Engineering, Inc.

For More Information Write In No. 379

FASTENING & ASSEMBLY SOLUTIONS

Find out how Camcar Textron's broad line of fasteners, cold formed components, assemblies and innovative services, including the TORX PLUS® Drive System, fasteners for metals and plastics and more, can improve productivity, enhance quality and lower costs. Call: 800-544-6117 for immediate information.

Camcar Textron

For More Information Write In No. 380

New on Disk

Mathcad 6.0 for Windows **mathematical software** from MathSoft Inc., Cambridge, MA, integrates World Wide Web and Lotus Notes connectivity, messaging and authoring features, and math, science, and engineering calculation tools in a single environment. The 32-bit program features new statistics and data analysis functions, visualization tools, and text formatting. The PLUS Professional Edition costs $349.95; the Standard Edition is $129.95.

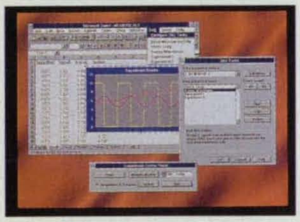
For More Information Write In No. 720

HEM Data Corp., Southfield, MI, has released Snap-Master General Analysis 3.0 **data analysis software.** An Equation Builder guides users through statistical analysis, digital filtering, integration, differentiation, arithmetic, and correlation functions. The Windows-based program is priced at $495.

For More Information Write In No. 721

Working Model® version 3.0 **motion simulation software** from Knowledge Revolution, San Mateo, CA, features new parametric design capabilities, a scripting language for user customization, a faster dynamics engine, and more file export choices. Product engineers can test mechanical systems in early stages. The cost: $2495.

For More Information Write In No. 722

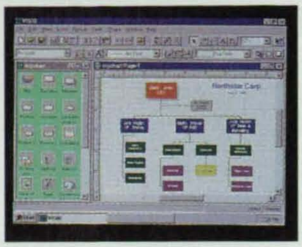


National Instruments, Austin, TX, has introduced Measure™ **data acquisition and serial control software**, a Windows-based spreadsheet add-on that combines Microsoft Excel with interactive menus for direct data acquisition, analysis, and report generation. The program costs $495.

For More Information Write In No. 723

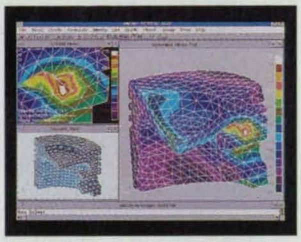
WorldUp™ **virtual reality and simulation software** from Sense8™ Corp., Mill Valley, CA, allows modification of real-time object behavior and scene characteristics while the simulation is running. Based on the WorldToolKit™ program, it does not require C programming, but rather, uses an interpreted language similar to Visual Basic and a graphic user interface based on Windows and Motif components. It includes tools for modeling, building, and animating objects and environments, and accepts 3D models created in other CAD packages. Prices start at $3500.

For More Information Write In No. 725



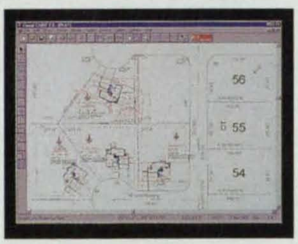
Visio Corp., Seattle, WA, has introduced version 4.0 of Visio® and Visio Technical **drawing and diagramming software**. Optimized for Windows 95 and other Windows-based programs, Visio is designed for creating a range of diagrams; Visio Technical is for creating and sharing 2D drawings and technical schematics. Both versions create flowcharts, time lines, management diagrams, and geographic maps. Visio is priced at $249; Visio Technical is $399.

For More Information Write In No. 724



FEA PowerSystem 95 v5.4 **finite element analysis software** from Aegis Software Corp., Pittsburgh, PA, allows finite element analysis of CAD solid model designs on a Windows-based PC system. Solid models from most CAD programs can be translated, and surfaces and solids can be meshed automatically with an optional module. Static, dynamic, and thermal analysis input files are translated directly and launched automatically from a preprocessor. Prices start at $2995.

For More Information Write In No. 726



Numera Software, Seattle, WA, has introduced a Windows 95-based version of Visual CADD **2D drafting software**. Mechanical engineers can use any Windows programming language or the built-in scripting language to customize the program. The new version is 300% faster, and features enhanced output capabilities and compatibility with other CAD programs, including AutoCAD. The software costs $595.

For More Information Write In No. 727

For More Information Write In No. 448

Product of the Month

Parker Hannifin Corp., Compumotor Division, Rohnert Park, CA, has introduced the ZETA Drive **microstepping motor/drive system** incorporating three patent-pending features: electronic damping, built-in stall verification, and electronic viscosity for greater usable torque and reduced settling time. According to the company, it is the fastest and smallest microstepping drive of its type, and is an alternative to open loop motion control systems. The drive measures 8.8" x 2" x 6.1", handles torques from 65 to 400 oz.-in., and operates at continuous speeds to 3000 RPM. ASIC-controlled microstepping is provided in 16 standard, selectable resolutions to 50,800 steps per revolution.

For More Information Write In No. 700

The Metricor 2000 modular, multi-parameter **fiber-optic sensor system** from Photonetics Inc., Wakefield, MA, measures over 20 physical parameters–such as temperature, pressure, and void fraction–for which over 50 application-specific probes are available. Any combination of probes can be mixed in a four-channel unit; single-channel and multiplexed units also are available.

For More Information Write In No. 701

The 1220DX **digital engineering copier/plotter** from JRL Systems Inc., Austin, TX, can be attached to a high-speed scanner for wide-format copying. It features enlargement, reduction, contrast adjustment, and copy count. The unit accepts input from an aperture card scanner, and enables scanned files to be saved and uploaded using optional software and a PC.

For More Information Write In No. 702

The VideoTherm 91S **infrared camera** from I.S.I. Group Inc., Albuquerque, NM, weighs only 4.5 pounds with the viewfinder and measures 4" x 4-3/8" x 7-3/8". The camera requires no coolants and features a built-in microphone. Images collected on videotape can be analyzed and enhanced with InfraSoft software that converts data from radiometric to temperature values.

For More Information Write In No. 703

The DataSYS 765 four-channel **direct recording oscilloscope** from Gould Instrument Systems Inc., Valley View, OH, is a waveform recording and transient capture instrument combining a traditional recorder and digital storage oscilloscope in one package. Users can record data directly to disks or memory cards at up to 250 k samples/second, or capture random events with durations of 10 ns.

For More Information Write In No. 704

The TP Series **air temperature monitoring switches** from Cambridge AccuSense Inc., Shirley, MA, can be installed anywhere in the cooling airflow to monitor ambient air temperature upstream or downstream of cardcages, power supplies, or filters. The solid-state, hysteresis-free switches operate from 0° C to 70° C and are compatible with most logic, relays, and indicators. They can trip at either one or two specified temperature setpoints with +1° C accuracy.

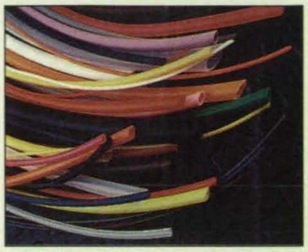
For More Information Write In No. 705

Precision Navigation Inc., Mountain View, CA, has announced the AX100 DHS and AX100 EGI **navigation devices**. The DHS is an attitude heading reference system that provides compass, tilt, and rotation information, and is designed to replace mechanical or fiber-optic gyroscope systems. The EGI is an inertial navigation unit with an embedded GPS receiver that provides position, direction, and orientation.

For More Information Write In No. 706

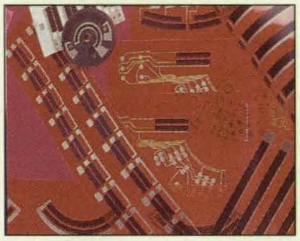
Bishop Wisecarver Corp., Pittsburg, CA, has introduced the HEPCO Ring and Track **linear motion system** for applications such as pick-and-place units, robots, and laser engravers that require circular, oval, and other curved linear motion in any plane. The steel ring and oval slides provide 90°, 180°, or 360° circular motion around nine diameters from 105 mm to 1109 mm.

For More Information Write In No. 707



M.M. Newman Corp., Marblehead, MA, has introduced custom **extruded Teflon® tubing** formulated of TFE, FEP, and PFA in flexible paste or rigid granular types with graphite, carbon, and glass fillers. Available in custom colors and sizes, it operates from -268° C to +260° C and is chemically inert, nonflammable, and suitable for use in industrial, medical, and laboratory applications.

For More Information Write In No. 709



The Sensorpad™ **position sensing element** from New England Instrument, Woonsocket, RI, integrates either internally or externally a military-grade position sensor into any device requiring position feedback. The sensing element is thin, frameless, and can be rigid or flexible with physical characteristics that may be modified for specific applications. It can be used in servo control systems, robotics, medical instrumentation, gimbals/actuators, and transducers.

For More Information Write In No. 710

Tektronix Inc., Beaverton, OR, has announced the THS 710 and THS 720 TekScope handheld **oscilloscope/digital multimeter** for troubleshooting electronic equipment. The device has an integrated 3-3/4-digit, 4000-count DMM with RMS for basic voltage, current measurement, and data logging. It is available with a portable printer, external fast charger, and additional voltage and current probes.

For More Information Write In No. 711

The Summa Expert™ **computer digitizer tablets** from Summagraphics Corp., Austin, TX, are 12" x 12" and 12" x 18" tablets with an intuitive interface for 3D rendering, CAD, graphic design, animation, and multimedia development. They provide 256 levels of pressure and are available with three pointing options: a cordless, three-button, pressure-sensitive pen; a cordless, four-button, articulating cursor; or a cordless, 16-button cursor. Accompanying software provides compatibility with PC and Mac platforms.

For More Information Write In No. 712

Elmo Mfg. Corp., New Hyde Park, NY, has introduced the Model 1322N **color monitor** that measures 13" diagonally and features a front-panel A/B switch. Other features are switchable B and C camera inputs with loop-through for both, and automatic V-hold circuitry. Front-panel picture controls include contrast, brightness, and color rendition. The monitor can be used for most color applications with over 300TV (H) line resolution.

For More Information Write In No. 713

The MVS modular **machine vision system** from Imaging Technology Inc., Bedford, MA, is available in two pre-packaged, expandable configurations for systems integrators and OEMs in machine guidance, industrial inspection, biomedical image analysis, and defense applications. The Windows-based system consists of image vision processing hardware and software, including a SVGA graphics board, two color monitors, a keyboard, and a mouse.

For More Information Write In No. 714

The VMC 186/40-TQ **four-axis motion controller** from Delta Computer Systems Inc., Vancouver, WA, provides coordinated position control and equipment or material movement for automation systems that use the VME Open Bus architecture and employ both quadrature encoders and magnetostrictive displacement transducers. It is designed for steel, plastic, rubber, automotive parts, and other manufacturing production line automation applications.

For More Information Write In No. 708

Paroscientific Inc., Redmond, WA, offers a six-page brochure of Digiquartz® **pressure instrumentation** products. Included are transducers, transmitters, depth sensors, pressure computers, fiber-optic systems, barometers, and portable standards.

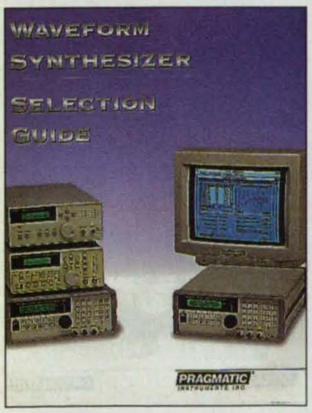
For More Information Write In No. 740

3D Systems, Valencia, CA, has released a six-page brochure on QuickCast™ **metal parts manufacturing technology** for rapid prototyping before the hard-tooling process. The technology replaces wax patterns with resin patterns, and cuts production time of metal parts.

For More Information Write In No. 741

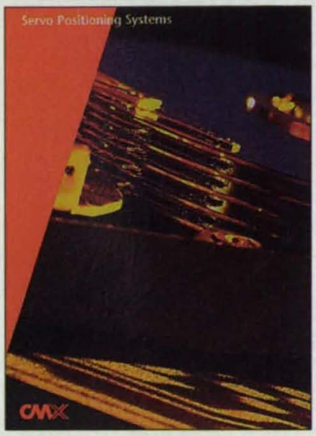
A technical reference catalog from Edmund Scientific Co., Barrington, NJ, describes **optical and science products** such as lenses, achromats, and prisms. Video microscopy systems, microscopes, magnifiers, lab equipment, and accessories also are included.

For More Information Write In No. 742



Pragmatic Instruments, San Diego, CA, has released a four-page selection guide for **waveform synthesizers** used in automotive, communications, medical, scientific, and semiconductor applications. Included are product configurations and waveform creation software.

For More Information Write In No. 743



An eight-page brochure from CMX Systems Inc., Wallingford, CT, describes **servo positioning systems**. A description of the fringe counting interferometry technology on which the systems are based also is included.

For More Information Write In No. 746

A 76-page catalog of **compressed air products** from EXAIR Corp., Cincinnati, OH, features vortex tubes, cabinet coolers, air knives and amplifiers, and static eliminators. Solutions to common industrial cooling, cleaning, drying, conveying, and static control problems are offered.

For More Information Write In No. 744

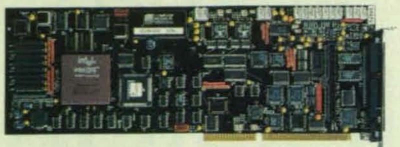
Bayer Corp. Polymers Division, Pittsburgh, PA, offers a 16-page brochure describing Apec **high-heat polycarbonate** that combines heat resistance, transparency, color stability, and flowability. Melt viscosity/flow and electrical properties are included.

For More Information Write In No. 745

An 82-page catalog from Barber-Colman Co., Rockford, IL, describes subfractional horsepower **AC and DC motors and gear motors**, including AC shaded pole and DC permanent magnet motors. Also included are features, applications, performance characteristics, and specification guidelines for selecting optional feedback devices.

For More Information Write In No. 747

DATA ACQUISITION



DAP 3200e™ with onboard 486

- High Speed I/O
- DSP Commands
- Multiboard Systems
- Most PC Software
- DAPtools for HP VEE
- Control Loop < 1 ms
- Windows, OS/2 Warp
- External Expansion
- DLL, VBX, Delphi
- DASY*Lab*, LabVIEW

MICROSTAR LABORATORIES™
the onboard intelligence company

206-453-2345
206-453-3199 fax
info@mstarlabs.com
www.mstarlabs.com/mstarlabs/

For More Information Write In No. 580

FREE! 130 Page Catalog

"Optics for Industry"

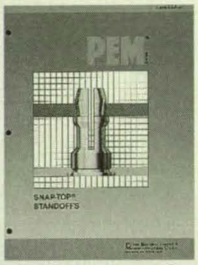
Free 130 page product catalog from Rolyn, world's largest supplier of "Off-the-Shelf" optics. 24-hour delivery of simple or compound lenses, filters, prisms, mirrors, beamsplitters, reticles, objectives, eyepieces plus thousands of other stock items. Rolyn also supplies custom products and coatings in prototype or production quantities. **ROLYN OPTICS Co.,** 706 Arrowgrand Circle, Covina, CA 91722-2199, (818)915- 5707, FAX (818)915-1379

For More Information Write In No. 581

Apollo 11 Commemorative Sweatshirt

Striking full-color illustration on quality white shirt recaptures the spirit and excitement of the Apollo moon landing. Available in adult sizes–S,M,L,XL $19.95 each plus $5.00 shipping/handling.
(NY residents add sales tax.)

Mail with payment to: Associated Business Publications 317 Madison Avenue, Ste 921, New York, NY 10017.
For credit card orders call (212) 490-3999



PEM® SNAP-TOP® STANDOFFS

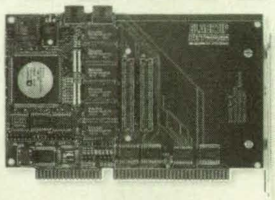
(Bulletin SSA)

PEM® SNAP-TOP® standoffs are designed for permanent installation into metal panels or PC boards. They use a spring action to hold PC boards and subassemblies securely, while allowing for quick removal. Screws and other threaded hardware are eliminated. To install, simply press into punched or drilled holes. Contact Penn Engineering & Manufacturing Corp., P.O. Box 1000, Danboro, PA 18916. Fax: 215-766-0143 or call: 1-800-237-4736.

Clinch it with PEM®
FASTENERS & PRESSES

For More Information Write In No. 582

100 MFLOP OEM-DSP $889 QTY 100



BLACKTIP

- Analog Devices ADSP-2106x SHARC floating-point DSP
- Up to 512K×48 external SRAM
- Flexible high-speed I/O site
- Two external link ports
- Half-length ISA card
- Free evaluation packages from Hyperception, Ixthos, and Wideband Computers with purchase of development SW

BITTWARE RESEARCH SYSTEMS
The SHARC tamers.
800-848-0436
33 North Main Street • Concord, NH 03301
FAX: 603-226-6667 • E-Mail: bittware@bittware.com

For More Information Write In No. 583

Official *NASA Tech Briefs* Cap

Sporty poplin cap perfect for golf or any outdoor activity. Red and black NASA Tech Briefs logo on white cap. Size adjustable. $9.95

Name ______________________
Address ______________________
City ______________________
State __________ Zip __________

Mail with payment to: Associated Business Publications 317 Madison Avenue, Ste 921, New York, NY 10017.
For credit card orders call (212) 490-3999

Call our AutoFAX 916-753-0618 from your FAX. Ask for data sheet #34. Also ask about our $99 evaluation kit.

The SmartCore™ is a shortcut to a custom-designed controller. It is a C-programmable microprocessor core with memory, supervisor, DMA, and clock already built in. All you need to do is add interface and control logic.

Z WORLD ENGINEERING
1724 Picasso Ave.
Davis, CA 95616
916.757.3737
916.753.5141 FAX

For More Information Write In No. 584

You *Can* Turn Your PC Into A Waveform Recorder!

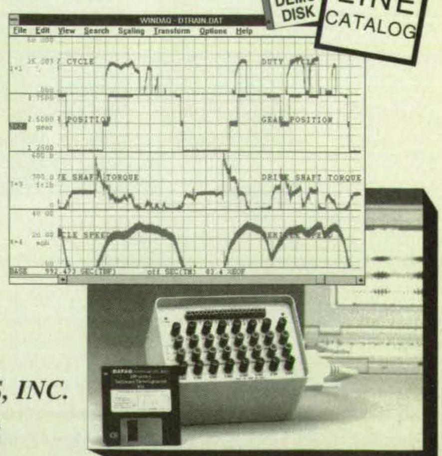
Today's most advanced data recording systems are not paper chart recorders. They're paperless, PC-based data acquisition systems from Dataq Instruments. We've replaced traditional instruments in a variety of applications with low-cost and flexible alternatives that save our customers thousands in paper costs alone. Factor in the productivity gains of computer-based analysis, and you have a solution you can't afford to ignore.

- Battery-powered and desktop solutions
- Hard copy to any graphics printer
- Sample rates of 1 to 500,000 Hz
- Connects from 1 to 240 channels to any PC

CALL FOR FREE INFORMATION

FULL LINE CATALOG

DEMO DISK



DATAQ *INSTRUMENTS, INC.*
800-553-9006

For More Information Write In No. 585

Advertisers Index

*RAC stands for Reader Action Card. For further information on these advertisers, please write in the RAC number on the Reader Action Card in this issue. This index is compiled as a service to our readers and advertisers. Every precaution is taken to insure its accuracy, but the publisher assumes no liability for errors or omissions.

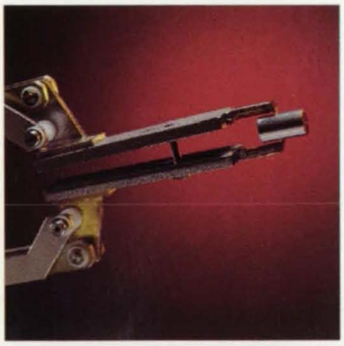
NASA Tech Briefs, ISSN 0145-319X, USPS 750-070, copyright© 1995 in U.S., is published monthly by Associated Business Publications Co., Ltd., 41 E. 42nd St., New York, NY 10017-5391. The copyrighted information does not include the (U.S. rights to)individual tech briefs which are supplied by NASA. Editorial, sales, production and circulation offices at 41 East 42nd Street, New York, NY 10017-5391. Subscription for non-qualified subscribers in the U.S., Panama Canal Zone, and Puerto Rico, $75.00 for 1 year $125.00 for 2 years; $200.00 for 3 years. Single copies $10.00. Foreign subscriptions one-year U.S. Funds $195.00. Remit by check, draft, postal, express orders or VISA, MasterCard, or American Express. Other remittances at sender's risk. Address all communications for subscriptions or circulation to NASA Tech Briefs, 317 Madison Ave., New York, NY 10017-5391. Second Class postage paid at New York, NY and additional mailing offices.

POSTMASTER: please send changes to NASA Tech Briefs, P. O. Box 10523, Riverton, NJ 08076-0523.

Statement of Ownership

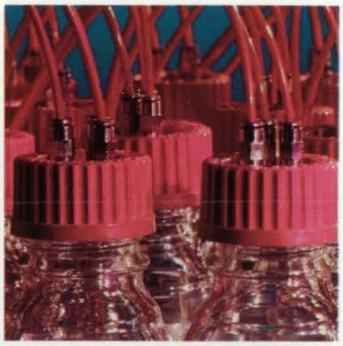
U.S. Postal Service Statement of Ownership, Management and Circulation (Required by 39 U.S.C. 3685) 1. Publication Title: NASA Tech Briefs 2. Publication No.: 1057-0411 3. Filing Date: 9/11/95 4. Issue Frequency: Monthly 5. No. of Issues Published Annually: 12 6. Annual Subscription Price: $75.00 7. Complete Mailing Address of Known Office of Publication (Street, City, County, State and Zip+4) (Not printer): Associated Business Publications Company Limited, 317 Madison Avenue, New York, NY 10017-5391 8. Complete Mailing Address of Headquarters or General Business Offices of the Publisher (Not printer): Associated Business Publications Company Limited, 317 Madison Avenue, New York, NY 10017-5391 9. Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor. Publisher (Name and Complete Mailing Address): Joseph T. Pramberger, Associated Business Publications Company Limited, 317 Madison Avenue, New York, NY 10017-5391; Editor: (Name and Complete Mailing Address): Linda L. Bell, Senior Editor, Associated Business Publications Company Limited, 317 Madison Avenue, New York, NY 10017-5391; Managing Editor: None 10. Owner (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding 1 percent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address as well as that of each individual must be given. If the publication is published by a nonprofit organization, its name and address must be stated.) Full Names and Complete Mailing Addresses: William Schnirring, Melissa Schnirring, Luke Schnirring, Domenic Mucchetti, Joseph Pramberger, all at Associated Business Publications Company Limited, 317 Madison Avenue, New York, NY 10017-5391 11. Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages or Other Securities. Full Name and Complete Mailing Address: None 12. For Completion by Nonprofit Organizations Authorized To Mail at Special Rates. The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes: not applicable 13. Publication Name: NASA Tech Briefs 14. Issue Date for Circulation Data Below: September 1995 15. Extent and Nature of Circulation (Average No. Copies Each Issue During Preceding 12 Months/Actual No. Copies of Single Issue Published Nearest to Filing Date): a. Total No. Copies (Net Press Run): 213,518/214,098 b. Paid and/or Requested Circulation: (1) Sales through Dealers and Carriers, Street Vendors and Counter Sales (Not Mailed): None/None (2) Paid or Requested Mail Subscriptions (Include Advertisers' Proof Copies/Exchange Copies): 204,991/207,088 c. Total Paid and/or Requested Circulation (Sum of 15b(1) and 15b(2)): 204,991/207,088 d. Free Distribution by Mail (Samples, Complimentary, and Other Free): 4,512/4,883 e. Free Distribution Outside the Mail (Carriers or Other Means): 3,515/1,627 f. Total Free Distribution (Sum of 15d and 15e): 8,027/6,510 g. Total Distribution (Sum of 15c and 15d): 213,018/213,598 h. Copies Not Distributed (1) Office Use, Leftovers, Spoiled: 500/500. (2) Return from News Agents: None/None i. TOTAL (Sum of 15g, 15h(1) and 15h(2): 213,518/214,098. Percent Paid and/or Requested Circulation (15c/15g x 100): 96.01%/96.72% 16. This Statement of Ownership will be printed in the October 1995 issue of this publication. 17. I certify that all information furnished on this form is true and complete. I understand that anyone who furnishes false or misleading information on this form or who omits material or information requested on the form may be subject to criminal sanctions (including fines and imprisonment) and/or civil sanctions (including multiple damages and civil penalties): Joseph T. Pramberger, Publisher.

Our technology is flowering.

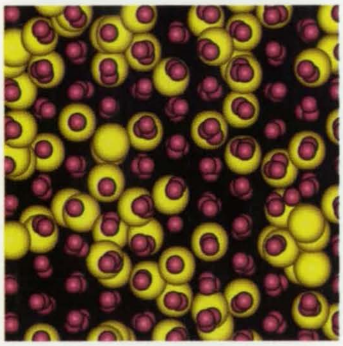


robotics

Savannah River Technologies



bioremediation



hydrogen

sensors

vitrification

At the **Savannah River Technology Center**, new solutions are taking root. We've treated over two billion gallons of contaminated ground water, more than any other Department of Energy site. We're developing technologies to vitrify radioactive, hazardous, and mixed waste. Our advancements in bioremediation, hydrogen handling and storage, sensors, and robotics demonstrate the vast resources of the Savannah River Site and the expertise of our people.

The Savannah River Site offers fertile ground for developing new ideas. Come join us in cultivating tomorrow's technologies. For more information contact E. Terrence Dailey, Westinghouse Savannah River Company, Aiken, South Carolina 29808 **[800] 228-3843**.

Westinghouse Savannah River Company
U.S. Department of Energy

See us at Technology 2005 **Booth 709**

For More Information Write In No. 605